

AD-A273 410

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED		
10 Oct 93		Annual		
4. TITLE AND SUBTITLE Research Interests of Broad Agency Announcement 94-1		5. FUNDING NUMBERS		
6. AUTHOR(S)				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) AFOSR 110 Duncan Ave. Suite B115 Bolling AFB DC 20332 CCOI		8. PERFORMING ORGANIZATION REPORT NUMBER		
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) SCIME GS 7		10. SPONSORING / MONITORING AGENCY REPORT NUMBER		
11. SUPPLEMENTARY NOTES				
12a. DISTRIBUTION / AVAILABILITY STATEMENT Unlimited		12b. DISTRIBUTION CODE		
<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 10%; text-align: center;">DISTRIBUTION STATEMENT A</td> <td style="width: 90%; text-align: center;">Approved for public release; Distribution Unlimited</td> </tr> </table>		DISTRIBUTION STATEMENT A	Approved for public release; Distribution Unlimited	
DISTRIBUTION STATEMENT A	Approved for public release; Distribution Unlimited			
13. ABSTRACT (Maximum 200 words)				
				
14. SUBJECT TERMS		15. NUMBER OF PAGES		
		16. PRICE CODE		
17. SECURITY CLASSIFICATION OF REPORT Unclass	18. SECURITY CLASSIFICATION OF THIS PAGE Unclass	19. SECURITY CLASSIFICATION OF ABSTRACT Unclass	20. LIMITATION OF ABSTRACT Unclass	

NSN 7540-01-280-5500

Standard Form 298 (Rev 2-89)
Prescribed by ANSI Std Z39-18
298-102

RESEARCH INTERESTS
and
BROAD AGENCY
ANNOUNCEMENT
94-1
of the
AIR FORCE OFFICE OF SCIENTIFIC RESEARCH



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RESEARCH INTERESTS OF THE AIR FORCE OFFICE OF SCIENTIFIC RESEARCH

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Supersedes AFOSR Pamphlet 70-1, October 1992 (see signature page for summary of changes).

No. of Printed Pages: 59

OPR: PKZ (Roger Goldenberg)

Approved by: Dr. Helmut Hellwig, Director

Distribution: F

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FOREWORD

Today the United States is second to none in military capability. This is a direct result of research and development carried out in the past; it has provided us the necessary technology for the present. Only a vigorous, focused, and diversified research program can provide our Nation with the required depth and scope of options for new and advanced technologies to meet future challenges.

The Air Force Office of Scientific Research (AFOSR) is charged with directing the Air Force's basic research program. This program includes both engineering and scientific research. The goals of this program are:

- to maintain technological superiority in the scientific and engineering areas relevant to Air Force needs;
- to prevent technological surprise to our Nation and create it for our adversaries;
- to maintain a strong research infrastructure composed of Air Force laboratories, industry, and universities; and
- to complement the national research effort.

Through grants to university scientists, academic support, contracts for industry research, and support for basic research in Air Force laboratories, funded at more than \$200 million for Fiscal Year 93, we support approximately 1,300 grants and contracts to about 350 academic institutions and industrial firms.

AFOSR works closely with the Air Force laboratories to transition extramural research to the exploratory development programs of these laboratories. In addition, the laboratories participate in the selection of AFOSR research topics in areas of Air Force needs. To this end, we are encouraging those who prepare proposals to contact appropriate activities in the Air Force laboratories. The *Directory* section of this pamphlet provides some initial contact points to assist you in this.

This pamphlet will guide you in your efforts to participate in our research program. To facilitate the preparation of proposals, the pamphlet is divided into five sections:

The *Introduction* section describes Broad Agency Announcement, the mechanism used by AFOSR to solicit research proposals. It also provides an overview of the general approach used to submit proposals.

The *Research Interests* section describes the basic research AFOSR is interested in sponsoring.

The *Academic Support Programs* section discusses research assistantship programs, faculty programs, and graduate school programs. Most of these programs foster mutual research interests between the Air Force laboratories and institutions of higher education.

The *Proposal Guidance* section represents a reprint of our general Broad Agency Announcement, BAA94-1, which provides detail about the proposal process.

The *Directory* lists the names, telephone numbers, and addresses of AFOSR scientific directors and program managers, Air Force chief scientists, and Air Force laboratory task managers.

Anyone qualified to perform research is encouraged to contact AFOSR in accordance with the appropriate BAA and the guidelines given in this pamphlet. We particularly encourage proposals from Historically Black Colleges and Universities, minority institutions, and minority researchers.


HELmut HELLWIG
Director

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Introduction

The Air Force Office of Scientific Research (AFOSR) manages all basic research conducted by the U.S. Air Force. To accomplish this task, AFOSR solicits proposals for research through a general Broad Agency Announcement (BAA) and through specialized BAAs published in the *Commerce Business Daily*.*

This general BAA outlines the Air Force Defense Research Sciences Program and is reprinted in Section IV, *Proposal Guidance*, for your convenience. AFOSR invites proposals for basic research in many broad areas. Section II of this pamphlet describes those areas in greater detail.

Specialized BAAs outline specific Air Force high-interest programs. Examples of recent BAAs include the University Research Initiative (URI) and Historically Black Colleges and Universities (HBCU) programs. HBCUs and minority institutions (MIs) are those institutions determined by the Secretary of Education to meet the requirements of 34 Code of Federal Regulations (CFR), Section 608.2, and 34 CFR, Subpart 637, respectively. Portions of this pamphlet may be applicable to the research opportunities described in these specialized BAAs as well.

Each BAA specifies deadlines, proposal formats, and other unique requirements. Unnecessarily elaborate brochures or presentations beyond those sufficient to present a complete and effective proposal are not desired. All proposals must be submitted in hard-copy form directly to the office listed in the applicable BAA. Be sure to mark your proposal with the specific BAA number to ensure that it receives proper consideration. Information about current BAAs is available from the address below. In addition, the *AFOSR Proposer's Guide* (AFOSR Pamphlet 70-11) describes procedures to follow when submitting proposals.

Before submitting a research proposal, you may wish to further explore proposal opportunities. This can

be done by contacting the AFOSR program manager, who can provide greater detail or who may ask for a preliminary proposal; however, in your conversations with any Government official, be aware that only contracting officers are authorized to commit the Government. Names and telephone numbers of AFOSR program managers are listed in Sections II and III of this pamphlet.

If you would prefer or if the program manager requests a preliminary proposal, this should be in letter format and briefly describe the following: (1) objective; (2) general approach; (3) impact on Department of Defense (DOD) and civilian technology; and (4) any unique capabilities or aspects such as collaborative research activities involving Air Force, DOD, or other Federal laboratories. Preproposal letters should not exceed three typewritten pages, but example figures and one-page vita(e) for the principal investigator(s) may be attached.

To obtain additional copies of this pamphlet or the *AFOSR Proposer's Guide*, send a self-addressed label with your request to:

AFOSR/XPT

110 Duncan Avenue, Suite B115

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General information can be obtained by calling (202) 767-4910. EOD personnel can call DEFENSE SWITCH NETWORK (DSN) 297-4910.

This pamphlet, as well as other AFOSR publications, may be downloaded from the Federal Information Exchange (FEDIX), an on-line information system accessible via computer and modem. Call the FEDIX computer at (800) 783-3349 (eight data bits, one stop bit, no parity). There is no charge to the user for accessing the information. The FEDIX help line is available at (301) 975-0103 from 8:30 a.m. until 5:00 p.m. e.s.t.

* The CBD publishes synopses of proposed U.S. Government contract actions that exceed \$25,000 in value. Subscriptions to the CBD are available from the Superintendent of Documents, Government Printing Office, Washington, DC 20402-9371, Tel. (202) 783-3238.



Research Interests

Aerospace and Engineering Sciences

- Structural Dynamics, Dr. Wu 13
- Mechanics of Materials, Dr. Jones 13
- Particulate Mechanics, Maj. Lewis 13
- Structural Mechanics, Dr. Chang 14
- External Aerodynamics and Hypersonics,
Dr. Sakell 14
- Internal Fluid Dynamics, Maj. Fant 15
- Turbulence Prediction and Control,
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Research in aerospace sciences addresses fundamentals of solid mechanics and structures, fluid mechanics, and propulsion. The goal of the research programs is to develop science-based knowledge for Air Force weapons systems (aircraft, missile, and space platforms) and facilities applications. The investment strategy strives for coherence and balance among three areas: scientific merit, Air Force relevance, and critical technology thrusts in areas where major advances in basic technology can be achieved through AFOSR investment.

Structural Dynamics

This research is to improve understanding of nonlinear behavior in aerospace structures, seeking advanced concepts for predicting the aerodynamic responses under extreme environment, and development of new integrated structural control models to enhance the performance of precision aerospace systems.

The program emphasizes the system stability and response of structures subjected to aerodynamic, gust, and thermal loads and complex interactions with fluids. We are particularly interested in the effects arising from aero-structure-control interactions.

Research topics of interest include energy transfer and dissipation mechanisms, dynamic instability, system identification, and aeroelasticity. We support development of new structural control approaches for suppressing vibrations, computing the time-varying structural configurations, and investigating the robustness of controlled multibody systems. We also seek the capability to model accurately structural-thermal interactions, including the structural response to intense thermal radiation and thermal diffusion through multilayered, actively cooled structures exposed to aerothermodynamic heating and surface reactions in hypersonic flight.

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Mechanics of Materials

Research in this program seeks to establish the fundamental understanding required for predicting the mechanical performance of aerospace structural materials when subjected to thermomechanical and environmental loading that simulates expected service conditions.

Projected Air Force applications will require multifunctional structures capable of sustained performance in extreme loading environments. Candidate structural material systems are almost all multiphase, highly heterogeneous media. These systems include metallic and intermetallic alloys, advanced composite material systems (including polymer-matrix, metal-matrix, ceramic-

matrix, and carbon-carbon composites), and solid rocket propellants and liners.

The continuing drive for safer, more durable aerospace vehicles with improved performance characteristics depends on researchers' ability to understand, characterize, and quantitatively model the expected behavior of such emerging material systems. Therefore, particular emphasis is placed on developing the mechanics principles and methodology appropriate for treating multiphase materials. Specifically, quantitative connections between evolving microstructural features and resulting performance parameters must be established. An analytical understanding of the relationship between processing and microstructure is also sought. Interdisciplinary approaches that include mechanics, materials science, chemistry, physics, and applied mathematics are encouraged, as are combined analytical-experimental efforts. Interaction with Air Force laboratory researchers who are conducting basic research is also encouraged, as well as with those in exploratory and advanced development programs.

Researchers in this program are aggressively pursuing constitutive models incorporating damage mechanism parameters as dependent variables, nonlinear fracture and damage mechanics, and physically founded stochastic approaches. Particular emphasis is placed on material systems that are capable of operation in extreme temperature environments, such as those to be utilized in future engine and airframe component designs. It is essential to develop innovative experimental methods for observing the response of materials to servicelike loading in real time and in appropriate environments, and to use these methods for in situ measurement of constituent properties and for damage evolution monitoring.

Researchers in this program also seek to understand and describe the structure and function of naturally evolved materials as a first step toward producing aerospace materials and structures with superior properties by imitating, to the extent possible, the processing and design principles found in nature.

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Particulate Mechanics

Particulate mechanics research aims to develop a fundamental understanding of the behavior of particulate materials based on first principles. Here, particulate materials are those that can be represented as an assemblage of physically discrete particles—either alone or in a matrix of materials having significantly different properties. Examples of particulate materials include metallic and ceramic powders used for manufacture of

advanced aerospace materials, powdered foods and cereal grains used in food preparation, and geologically derived materials such as soil, rock, and concrete.

Many current and future aerospace structural materials of interest to the Air Force are manufactured from powder precursors. The manufacturing process, and resultant product, are frequently dominated by the mechanical behavior of these powders, whether dry or in suspension. In addition, many current structural design and analysis methods are based on empirical relationships derived from phenomenological data and fail to address the fundamental behavior of these heterogeneous, anisotropic, multiphase material systems. It is recognized that the behavior of these materials is governed by the physics of the particle interactions. This research will provide a knowledge base from which analytical models can be developed to design and evaluate new material processing methods. Basic research in particulate mechanics will lead to improved material handling and processing technologies, and improved design and analysis methods, for aerospace systems and their supporting infrastructure.

Proposals for research in particulate mechanics should emphasize the behavior of particulate material systems with characteristic lengths that range from nanometers to meters. Interdisciplinary theoretical, analytical, and/or experimental approaches that include mechanics, materials processing science, physics, and applied mathematics are encouraged. We seek to obtain quantitative relationships to describe the fundamental mechanics of particulate material systems. Proposed research in this area should focus on the influence of material microstructure on overall constitutive behavior, the constitutive behavior of multiphase (heterogeneous) particulate systems, and localization and instabilities in particulate media, including their potential to flow and liquefy.

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Structural Mechanics

The objective of this research program is to provide the fundamental knowledge required to understand system behavior and ensure integrity of aerospace structures, including aircraft, missiles, and spacecraft. The program also supports computational and experimental research efforts leading to the development of improved systems and materials for the optimal performance of future aerospace structures.

This program seeks proposals for developing fundamental solid mechanics to better understand structural nonlinear characteristics and material inelastic behavior.

We are particularly interested in the correlation of local and global responses of structural systems, the deformation and fracture mechanisms in materials, and the measurement of their microstructural changes. The degradation of materials and structures over long periods of service is also of interest, since current Air Force weapon systems will remain in service much longer than originally anticipated.

Current topics of interest include nonlinear structural behavior, intelligent materials and structures, material instabilities, and the role of inhomogeneities at various scales in structural response and homogenization. We also seek improved numerical methods that will lead to a realistic simulation of failure phenomena.

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External Aerodynamics and Hypersonics

This research program seeks to improve the understanding of fluid flow phenomena that strongly influence the aerodynamic performance and efficiency of flight vehicles relevant to the Air Force's mission requirements. This program comprises three technical thrust areas: compressible turbulence, advanced computational fluid dynamics (CFD) research, and hypersonics. Research should focus on the physical mechanisms that govern these classes of complex flows.

The study of compressible turbulence comprises experimental, analytical, and computational research whose aim is to reveal the fundamental structure and properties of high-speed, compressible turbulence. Research is needed to determine the fundamental nature of compressible turbulence structure in complex shock-wave interaction flows with turbulent boundary layers. These flows routinely occur in engine inlets of supersonic and hypersonic flight vehicles and over advanced aircraft wings and missile shapes.

In advanced CFD research, unstructured grid methods are being developed. Research is ongoing to develop methods capable of simulating complex, three-dimensional, time-dependent flows created by aircraft platforms during dynamic maneuvers. These full Navier-Stokes simulations are three-dimensional and time-dependent and include viscous effects that range from laminar, through transitional, to fully turbulent boundary layer states. We are also interested in developing analysis capabilities for hypersonic engine inlet unstart processes.

Research in hypersonics should improve the understanding of complex, time-dependent, three-dimensional viscous flows with and without real gas effects and advance the accuracy of numerical simulation methods. We are especially interested in three-dimensional Burnett-

equation numerical methods and direct numerical simulation methods with rate chemistry. We are also interested in wind-tunnel research that investigates the fundamental fluid mechanics of high Reynolds number as well as high-enthalpy hypersonic flows.

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Internal Fluid Dynamics

Research in this area is motivated by problems relevant to the airbreathing propulsion requirements of the Air Force. This research focuses on understanding and controlling complex internal flows, as in axial flow compressors and axial flow turbines. Emphasis is on understanding the role of unsteadiness and three-dimensionality in design, performance, stability, and heat transfer to obtain more efficient and lightweight high-performance engines. We are exploring active control strategies for rotating stall and surge instability in gas turbine engine compressors as well as examining compressibility effects and the influence of inlet distortion on forced response. We are also developing improved understanding and predictive techniques for unsteady heat transfer in gas turbines.

The principal areas of concentration include high free stream turbulence, stagnation point heating and wing-body juncture flows, and transition heat-transfer phenomena. An important goal is to integrate fluid dynamics with heat transfer to aid in determining and modeling the key mechanisms responsible for high heat-transfer rates in these severe environments. Recently, we have begun to address high-speed, high-flow turning phenomena in direct support of low-aspect-ratio, high-work compressors and turbines.

We are interested in innovative research that illuminates the physical mechanisms governing internal flows in a rotating environment. We encourage an interdisciplinary approach to understanding and solving the problems associated with rotating stall and surge, incorporating bifurcation analysis and nonlinear control theory, to improve the modeling of compressor instabilities.

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Turbulence Prediction and Control

This research program seeks fundamental understanding of physical mechanisms governing the onset and evolution of turbulence in bounded and free shear flows.

It also seeks application of that understanding to develop advanced models and concepts for predicting and controlling turbulent and transitional flows.

We are interested in theoretical, computational, and experimental approaches to understanding flow instabilities and the mechanisms of transition from laminar to turbulent flow, in both bounded and free shear flows. We encourage research on the receptivity of transition to background and imposed flow disturbances. The dependence of transitional flow behavior on pressure gradient, three-dimensional base flows, and compressibility is of interest. Mixing in compressible shear layers is of special interest. We are also interested in research directed toward understanding the connection between chaotic advection and mixing in three-dimensional flows.

Research on the nature of turbulent heat transfer is also of interest, particularly in the context of turbine blade cooling. Innovative approaches to understanding, predicting, and controlling turbulent heat transfer are sought.

Direct numerical simulations of the temporal and spatial evolution of transitional and turbulent flows may provide insights into governing physical mechanisms, guide the formulation of new predictive models, and suggest innovative concepts for controlling aerodynamic lift and drag as well as turbulent mixing and transport. Of most interest are ideas to advance principles and methods for large-eddy simulation, especially subgrid modeling, and ideas to advance the understanding and prediction of turbulence at high Reynolds numbers. We seek original ideas and concepts leading to new approaches to turbulence modeling, especially ideas incorporating the physics of turbulence into predictive turbulence models.

We are interested in advanced diagnostics research that targets new concepts and new approaches for measuring and interpreting very large arrays of time- and space-resolved data. We seek new ideas for significantly advancing our experimental diagnostic capability in turbulent flows, providing time- and space-resolved data on fundamental flow structures and their interactions. Application of new diagnostic approaches to understanding turbulence-induced optical distortions is of special interest.

Research on the development of diagnostic sensors and integrated arrays of sensors and actuators, including neural network approaches, is of interest for application to flow control. The use of microelectromechanical systems in this context may offer promising new approaches. Innovative ideas on the use of helium as a working fluid for turbulence research at moderately high Reynolds numbers, incorporating integrated microdiagnostic techniques, are also of interest. We also seek collaborative, interdisciplinary research involving fluid dynamics and control theory that may lead to new approaches for controlling transition and turbulence.

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Unsteady and Separated Flows

This research program focuses on understanding and controlling unsteady separation and vortex development over lifting bodies in unsteady, high-angle-of-attack maneuvers. The emphasis is placed on three-dimensional lifting surfaces undergoing prescribed motion, although select quasi-two-dimensional lifting surfaces will be investigated to continue pursuit of a theoretical framework for unsteady separation and to elucidate the physics of compressibility effects on dynamic separation events. We emphasize enhancing aerodynamic performance, especially aircraft agility, through the understanding and control of energetic unsteady flow fields.

Principal areas of concentration include flow separation, leading-edge vortex development, and vortex breakdown from swept leading edges; evolution from flow separation to fully stalled flow on swept wings, including interactions between opposite leading-edge vortices; and identification of major elements of unsteady flow structure that determine unsteady loading and associated phase shift and dynamic hysteresis. The control of vortex breakdown and unsteady forebody flows, by either fluid-induced or structural perturbations, is also being investigated. This research directly contributes to improving nonlinear aerodynamic models that must account for history effects, hysteresis, and aerodynamic bifurcations to maintain sound flying characteristics in the pre- and poststall regimes. Recently, a new thrust was established to address the flow physics and fluid-structure interactions associated with the impingement of three-dimensional unsteady vortical flows upon wing and tail components; including limit cycle oscillations in the compressible flow regimes. We seek innovative proposals for basic experimental and computational investigations that will extend our understanding of the physical processes involved.

We encourage collaborative, interdisciplinary approaches involving fluid dynamics and control theory and fluid-structure interactions—approaches that will provide new ways of predicting, sensing, controlling, and interacting with unsteady flows. Basic interdisciplinary research combining unsteady aerodynamics and flight mechanics also is needed to understand and predict the behavior of vehicles and missiles performing unconventional dynamic maneuvers.

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Airbreathing Combustion

Fundamental understanding of the physics and chemistry of multiphase, turbulent reacting flows is essential to improve the performance of airbreathing propulsion systems.

We are interested in innovative research proposals that use simplified configurations for experimental and theoretical investigations.

Our highest priorities are studies of supersonic combustion, atomization and spray behavior of slurries and liquids, fuel combustion chemistry, and supercritical fuel behavior in precombustion and combustion environments. Other topics of interest include turbulent combustion, soot formation, and interactive control.

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Space Power and Propulsion

Wide-area surveillance and space-based defense require affordable on-demand/on-schedule launch and orbit transfer vehicles and accurate plume prediction models.

Research activities fall into two areas: nonchemical orbit-raising propulsion and chemical propulsion. Research in the former area is directed primarily at advanced space propulsion and is stimulated by the need to transfer very large payloads between orbits. It includes studies of the sources of physical (nonchemical) energy and the mechanisms of release. Our emphasis is on understanding electrically conductive flowing gases (plasmas) that serve to convert beamed or electrical energy into kinetic form. Theoretical and experimental investigations are being conducted on the phenomena of energy coupling and the transfer of plasma flows in electrode and electrodeless systems under plasmodynamic environments.

Topics of interest include characteristics of pulsed and steady-state plasmas; characteristics of equilibrium and nonequilibrium flowing plasma; characteristics of electrical and hydrodynamic flows; instabilities of plasma bulk and wall layers; interactions of plasma-surface, -electrode, -magnetic, and -electric fields; losses to inert parts; characteristics of plasmas in high-magnetic fields and pressures; ionized cluster beam formation for ion thrusters; and plasma diagnostics (new and unique non-interfering measuring techniques).

Research is being conducted on chemical propulsion to predict and suppress combustion instability in solid and liquid rocket systems, to control the complex role of advanced energetic ingredients in solid propellant burning, and to permit the use of metal fuels (studying condensation and oxidation dynamics of metal-atom-doped clusters).

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Propulsion Diagnostics

Research is directed at new techniques for sensing temperatures, concentrations of chemical constituents, and velocities in energy conversion systems without interfering with the operation of the systems. The research emphasizes diagnostics of laboratory systems that simulate the hostile environments of high-performance combustion and plasma systems and sensors for onboard control of propulsion systems.

Of interest are combustion and plasma flows, including multiphase reactions, gas-solid interactions, sprays, and reactions under supersonic conditions. We are exploring sensing and diagnostic techniques and strategies consistent with advances that are expected in adaptive controls. Topics include the quantitative imaging of plasma flows, monitoring rapid surface reactions, using nonoptical sensors, instantaneously mapping velocities, and formalisms for exploiting array data. We seek proposals that introduce techniques rather than apply advanced diagnostics as part of the research.

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CHEMISTRY AND MATERIALS SCIENCE

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Research in chemistry and materials sciences addresses five basic issues: processing chemistry, energy interconversion phenomena, characterization of the aerospace environment, metallurgy, and ceramics. More details of our special interests are outlined in this section. Besides our contract and grant program, we include in our overall program in-house research at two Air Force laboratories: the Wright Laboratory (materials, aeropropulsion and power, and armament) and the Phillips Laboratory (geophysics, rocket propulsion, lasers and imaging, and advanced weapons and survivability).

Chemical Reactivity and Synthesis

Through this research we seek new and better methods of preparing and characterizing new organic, organofluorine, and bio-organic compounds and material formulations. We explore associated reaction kinetics, reaction mechanisms, and molecular structure-property relationships, utilizing both theoretical and empirical methods. The overall goal is a technology base for future development of advanced materials with significantly improved properties, lower cost preparation, and positive environmental impact.

Current objectives include novel approaches to the molecular design and synthesis of organic polymers that will extend current long-term thermo-oxidative usage limitations. We are exploring materials compositions that may provide the optimal combination of physical, mechanical, and electronic properties for high-temperature electronic packaging applications. In the area of organofluorine chemistry, we seek organofluorine compounds with properties suitable for high-temperature lubricants and low-dielectric organofluorine polymers for high-temperature electronic packaging. We seek an understanding of the chemical behavior of aircraft turbine engine fuels under supercritical conditions with a goal of inhibiting degradation. In the biotechnology area, we are pursuing applications of bacteria and enzymes both to the synthesis of key aerospace chemical intermediates and to the degradation of environmentally hazardous aerospace materials. We are exploring the scope and mechanisms of biologically caused corrosion of advanced aerospace materials. We are seeking to understand and mimic design and crystal-growth processes found in naturally occurring systems in order to obtain improved structural and electro-optical materials. In the environmental area, we are investigating the surface and subsurface chemical and biochemical fate of hazardous aerospace materials that may be released into the environment. An investigation of mechanisms of suppression of uncontrolled combustion is under way. We are exploring design, preparation, and reaction mechanisms of fire suppression agents which may be candidates as replacements or alternatives for Halons. We are interested in molecular modeling studies utilizing theoretical, semiempirical, or intelligent data-

base development approaches to obtain predictive methods of correlating molecular composition with engineering properties, as well as validation of these studies through synthesis and characterization.

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Polymer Chemistry

The goal of this research is to gain a better understanding of the relationship between chemical structures, processing conditions, and properties of polymeric and organic materials for satisfying the current and future requirements of Air Force advanced systems. The approaches to meeting this goal include studying the chemistry and physics of these materials through synthesis, processing, and characterization.

One of the objectives of the current program is to study electronic nonlinear optical (NLO) organic and polymeric systems for photonic, electro-optical, and optoelectronic applications. A current emphasis is to identify physical and electronic mechanisms and chemical structures that can improve the second- and third-order macroscopic optical nonlinearity of polymeric materials beyond the state of the art. Improvements in processibility, optical quality, and temporal stability of these materials, especially for the second-order NLO materials, are highly desirable.

In the area of multifunctional polymers and polymeric systems, research is conducted to study the fundamentals in combining different properties in a single material system. This concept is being broadened to include ceramers, or alloy of ceramics and polymers. Many advanced devices and systems require a combination of different properties to operate properly. Combining these properties in a single material will provide an enabling material technology for many emerging applications, such as smart materials that can change their properties by responding to their environments in predetermined ways. Materials based on this concept will make it possible to combine different devices into one system, such as head-up display built into a canopy system.

Another goal of this concept is creating new properties through combinations of properties, such as generating photorefractivity through the combination of photoconductivity and electro-optical properties. An additional goal is to provide materials that possess coupled properties, so that the change of one property, either in a controlled fashion or otherwise, can change the other properties of the materials. These materials can be very useful for sensors and function controls.

Another area of interest is organic superconductivity. Research is being conducted to understand the

fundamental mechanism, thus the molecular requirement for superconductivity in organic or polymeric systems.

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Inorganic Materials Chemistry

Inorganic materials chemistry supports basic research on synthesis, processing, reactivity, and analysis of structural and nonstructural materials, thin films, and interfaces. The ultimate goal of this research is atomic-scale control in the chemistry and morphology of inorganic materials during the manufacturing process. The desire is to control chemistry at the atomic level—by depositing and removing individual atoms at specified atomic sites.

Advanced processing research encompasses solution ceramics, sol-gel glasses, quantum dots and quantum wires, and oxidation-resistant carbon-carbon composites. The goal of this research is to chemically manufacture structural, optical, and electronic materials exhibiting better performance and produced at a lower cost than what is currently available.

Surface chemistry research deals with the growth of thin films, tribochimistry, corrosion and materials degradation, and catalysis. The goal of this research is to determine the basic chemical phenomena which control epitaxy, ferroelectric behavior, friction and wear, and heterogeneous reactions.

The objective of this program is to use fundamental chemistry to manufacture unique electronic structures, to improve material reliability, and to achieve molecular control of materials processing. This will impact future Air Force communications systems, advanced avionics, 21st-century air vehicles, and new fuels and lubricants to match these vehicles' capabilities.

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Electrochemistry

Electrochemistry research is directed at fundamental aspects of electrochemical power generation and storage. Our program provides the technology for such devices as batteries, fuel cells, and photoelectrochemical cells.

Our focus is on materials used in electrochemical cells and processes occurring at the electrode-electrolyte interface. The electrochemical materials include non-traditional electrolytes, such as molten salts, polymers,

and solid-ion conductors. We are primarily interested in new materials that may improve battery performance and reliability. We seek to expand the fundamental understanding of electrode processes through the development of *ex situ* and *in situ* surface analysis, electrocatalysis, and electrode activation.

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Theoretical Chemistry

Theoretical chemistry research focuses on new theoretical tools and methodologies to permit accurate and timely calculations of materials properties of interest for Air Force applications. Applications of theory at Air Force laboratories are complemented by extramural research to create more capable, useful modeling tools. In particular, methods are needed to allow accurate and rapid calculation of molecular geometries, energies, lifetimes of excited states, rates of intermolecular energy flow, and kinetic parameters for elementary steps in chemical reaction mechanisms. A premium is placed on research which directly contributes to improvements in quality and efficiency of experimental programs to produce new materials. Materials systems of primary interest are energetic materials, lubricants, lightweight structural materials and electro-optical materials important to advanced aerospace technology. Technology transfer is achieved by creating managed linkages between theoretical and experimental programs to produce advanced materials more rapidly, more systematically, and at lower cost.

Predicting new materials structures using methods of theoretical chemistry is playing a vital role in guiding the efficient synthesis of new high-energy-density materials (HEDMs). This research supports the Phillips Laboratory objectives to develop space system propulsion technology to double the payload capability to geosynchronous earth orbit and halve the cost per pound to orbit. Phillips Laboratory scientists and AFOSR program managers in Theoretical Chemistry and Molecular Dynamics cooperatively manage an extramural program that complements Phillips Laboratory research to create high-specific-impulse propellants. Enormous time and research money is being saved by using theory to exclude proposed HEDMs that are not stable without having to attempt their synthesis and by predicting promising target molecules as candidates for synthesis.

Targeted support is provided complementing in-house research and development of the Wright Laboratory polymer chemistry program. This research supports development of nonmetallic multifunctional materials (laser-hardened materials, electro-optical

polymers, tribological coatings, and lubricants). Theory has been used to guide research to produce fast optical switches for pilots' eye protection against laser weapons. Software programs to predict electro-optics properties of molecules have been provided to Air Force laboratory scientists for this and other electro-optical applications. This software is also being adapted for commercial release. Significant progress has been achieved toward the laser hardened materials program to produce fast optical switches for an operational eye protection system. Also, calculations predicting atomic interactions at interfaces are being used to interpret and guide lubrication and wear experiments at Wright Laboratory, the Naval Research Laboratory, and IBM Almaden Research Center in support of programs to provide ultra high temperature propulsion system lubricants. Theory also contributes to Wright Laboratory programs in electronic and electro-optical materials; lightweight low observable structural materials; ceramics and very high temperature carbon/boron based materials for increased propulsion performance. In this research, emphasis is moving to create new algorithms which take advantage of parallel computer architecture to predict properties with chemical accuracy for systems having a very large number of atoms.

Theoretical predictions are used to describe ion-molecule chemistry in the highly excited upper atmosphere, providing input to models of atmospheric chemistry and kinetics used by the Geophysics Directorate of the Phillips Laboratory to predict ionospheric effects on Air Force systems.

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Molecular Dynamics

The objectives of the molecular dynamics program are to understand, predict, and control the reactivity and flow of energy in molecules. This knowledge will be used in atmospheric chemistry to improve our detection and control of signatures; in high energy density material research to develop new energetic materials for propellants and explosives; in chemical laser research to develop new high energy laser systems; and in many other chemical systems where predictive capabilities and control of chemical reactivity and energy flow at a detailed molecular level will be of importance.

Areas of interest in atmospheric chemistry include the dynamics of ion-molecule reactions relevant to processes in weakly ionized plasmas in the ionosphere; gas-surface interactions in space; and reactive and energy transfer processes that produce and affect radiant emissions in the upper atmosphere. In the latter, rotational

energy transfer processes are of particular current interest. Research on high energy density matter for propulsion applications investigates novel concepts for storing chemical energy in low-molecular-weight systems, the stability of energetic molecular systems, and the storage of energetic species in cryogenic solids. A new initiative will explore chemical reactivity in solids and how energy localization affects reactions in solids, that control the sensitivity of explosives. Research in energy transfer and energy storage in metastable states of molecules supports our interest in new concepts for chemical lasers. Fundamental studies aimed at developing predictive capabilities for and control of chemical reactivity, bonding, and energy transfer processes are encouraged.

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Metallic Structural Materials

Research addresses advanced metals, alloys, intermetallics, and metal matrix composites for engine, airframe, and spacecraft structural (load-bearing) applications.

The goal of this research is to provide the fundamental knowledge required to create, synthesize, process, design, and improve metals and alloys used in aerospace applications. Specific topics are metallurgy of structural materials, hybrid materials, computational materials science, fatigue and fracture, interface phenomena, processing science, high-temperature materials, intermetallic alloys, and metal matrix composites. Investigations are aimed at understanding the behavior of materials at ambient and elevated temperatures. Such behavior includes strengthening mechanisms, phase transformations, plasticity, creep, fatigue, environmental effects, dynamic and static fracture, and the experimental verification of theoretical and computational (atomistic) models.

Understanding the relationships between alloy chemistry, nano-micro-macrostructure, materials processing, and mechanical behavior is an essential aspect of this program. The scientific issues that drive this research include synthesis of nonequilibrium materials, nanoscale microstructures, interface phenomena, deformation processes, fatigue and fracture mechanisms, computational materials science as applied to alloy theory and alloy design, and experimental verification of theoretical predictions. The relationship of atomic and microstructural phenomena to bulk mechanical properties is a major focus of this research. The metallurgical systems of major interest are the intermetallics, refractory alloys, and metal matrix composites in general. The utilization of computer simulation, high resolution electron microscopy, transmission

electron microscopy, scanning electron microscopy, sophisticated processing, and other advanced laboratory techniques will add to the success of this research program. This year, specific emphasis will be on high-temperature materials. In addition, a Fiscal Year 94 initiative is planned on materials for hypersonic flight, including processing, characterization, mechanical property mechanisms, and property stabilization in these materials.

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Ceramics and Nonmetallic Structural Materials

The objective of this research program is to provide scientific background for current and future applications of ceramics, ceramic-matrix composites (CMC), and carbon-based composites. Ceramics, as a class of materials, are based on covalent and ionic bonds, both of which are much stronger than metallic or any other type of bonds present in other materials. This is why, in general, ceramic materials are very refractory and have high specific strengths and stiffness. In fact, some nitrides, carbides, and carbon-based materials retain nearly constant strength and stiffness from room temperature to over 2,000 °C. One of the major components of this program is understanding high-temperature strength and creep-resistance of ceramics on atomic and microscopic levels. The goal of this work is to provide reliable, creep-resistant, affordable materials for high-temperature structural applications that will lead to increased propulsion and vehicle performance. Of particular importance are creep-resistant oxide materials, such as yttrium aluminum garnet (YAG), alumina, and zirconia. Silicon nitride and silicon carbide are also investigated for very high temperature applications.

The attractive high-temperature properties of ceramics indicate the large potential benefits of using

ceramics, CMCs, and carbon-based materials in space structures and aeropropulsion. However, the same strong, directional bonds that entail the high refractiveness and strength also inhibit plastic deformation and lead to the well-known intrinsic brittleness of ceramics. The issue of reducing brittleness is addressed in three ways: (1) study of fracture, fatigue, and lifetime reliability of ceramics to establish criteria for predicting reliability of brittle materials; (2) evaluation of transformation toughening, flaw- and stress-induced toughening, and other techniques to produce tough, reliable ceramics; and (3) design, fabrication, and evaluation of fiber, laminate, and particulate CMCs that fracture in a metal-like, "graceful" manner. It is expected that fiber-reinforced CMCs will satisfy requirements for tough, reliable materials capable of prolonged operation at and above 1,500 °C. However, a number of scientific issues are yet to be solved. For example, for high toughness of CMCs, ceramic fibers should not be bound too strongly to the matrix. This requirement necessitates thermally stable, oxidation-resistant fiber matrix interfaces. How to protect fibers from chemically reacting with the matrix at 1500 °C and how to optimize properties of the fiber matrix interfaces are the complex CMC-related scientific issues that are currently emphasized by this program.

Lightweight, high-temperature-resistant carbon carbon composites are increasingly used as structural elements for hypersonic aircraft and space structures. To facilitate their use, the oxidation resistance of these materials must be improved. To this end, this program seeks to elucidate oxidation mechanisms of carbon materials with the goal of inhibiting oxidation by using dopants and surface modifiers. Also studied are carbon-like materials, such as BC₃, which resist oxidation better than carbon. In addition, new approaches to oxidation-inhibiting ceramic coatings for carbon-carbon composites are of interest.

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PHYSICS AND ELECTRONICS

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Research in physics and electronics provides the fundamental knowledge needed to advance Air Force operational capabilities in surveillance; guidance and control; information and signal processing; and communications, command, and control. The program is of substantial scientific breadth, extending from elementary and quantum physics, to understanding the performance of novel electronic devices, to engineering issues such as systems performance and electronic and photonic materials processing techniques. The program is carried out in collaboration with selected Air Force laboratories such as the Rome Laboratory, the Wright Laboratory, and the Phillips Laboratory.

Joint Services Electronics Program

The Joint Services Electronics Program (JSEP) is a mutual enterprise of the Army, the Navy, and the Air Force designed to provide the Department of Defense with a university-based research capability in the electronic sciences and related areas. Each of the 12 major universities currently involved in the program carries on a multidisciplinary research program in one or more of the following subjects: Solid-State Electronics (Devices, Materials, Integration); Electromagnetics (Waveguides, Propagation, Scattering, Antennas); Quantum Electronics and Optics; Information Electronics (Computers, Signal Processing, Communications, Circuits and Systems), together with interdisciplinary programs in physics, chemistry, engineering, mathematics, and materials science that are in support of these broad areas.

The JSEP is reviewed by the Tri-Service Technical Coordinating Committee (TCC), consisting of senior scientists or science administrators from the three services. The TCC has a continuing interest in the expansion of the JSEP, including the addition of new universities, provided future funding allotments and/or program changes in current JSEP universities make it advantageous. The TCC will give due consideration to proposals from universities desiring membership, taking into account the following criteria: a capability for performing high-quality, multidisciplinary research in the electronic and related sciences; a competent management structure with a highly capable individual fully responsible for the successful execution of the research program; a professional staff with recognized scientific competence; and a demonstrated capability in support functions and facilities.

Proposals should address the problems to be investigated, approaches to be used, expected results, qualifications of the principal investigators, and cost of the proposed research.

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Electronic Devices, Components, and Circuits

The research program encompasses a wide variety of advanced electronic structures and devices, primarily fabricated from compound semiconducting materials. A range of materials systems (e.g., gallium arsenide, indium phosphide, silicon-germanium alloys on silicon III-V nitrides, the antimonides, heteroepitaxial materials) and devices (such as pseudomorphic high-electron-mobility field-effect transistors, heterojunction bipolar transistors, resonant tunneling structures) are of interest—especially those structures exploiting quantum-mechanical effects. The use of silicon-germanium alloys for device applications is of particular interest. Special focus is placed on the understanding and applications of so-called low-temperature gallium arsenide and related layers. We seek research proposals in approaches to wafer-level integration such as selected area heteroepitaxy, the use of patterned substrates, and the lift-off layer technique.

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Optoelectronic Information Processing: Devices and Systems

This program includes investigations in two affiliated arenas: (1) the development of optical materials and optoelectronic devices and (2) the insertion of these components into optoelectronic computational and information-processing systems. Emphasis is on coordinating device exploration and architectural developments; synergistic interaction of these areas is expected, both in structuring architectural directions to reflect device capabilities and in focusing device investigations according to system needs.

Research in optical materials and devices focuses on insertion of optical technology into computing, image-processing, and signal-processing systems. This program continues to foster surface-normal interconnect capabilities, combining detector arrays with spatial light modulators or with optical modulator (or source) arrays at local processing elements. An ancillary emphasis explores optical memory capabilities demonstrated by persistent spectral hole-burning techniques, or by photorefractive materials, in page-oriented or holographic configurations. The investigation of spectral diversity in processing, implemented by devices that enable emission, transmission, filtering, and switching is also being pursued. Understanding the fundamental limits of the interaction of light with matter is important. Semiconductor technology incorporating engineered materials is

encouraged to implement device components. The devices considered under this program will be high speed, low energy, and robust and will incorporate gain, logic, or memory capabilities, with prospects for array configurations. This approach will lead to "building block" components that can be used in diverse optical implementations.

System-level investigations incorporate these devices into processing architectures, taking advantage of their demonstrated and envisioned attributes and determining appropriate problem classes for optical or optoelectronic approaches. The computational advantages and proper use of parallelism provided by optical implementations continue to guide architecture and device development. In addition, a new emphasis is evolving, stressing the use of the inherent extremely wide bandwidth of optical carriers. Computer processing components continue to encounter increasing difficulty in signal transmission, constrained by wire-crossing restrictions, electromagnetic interference, and crosstalk, an impediment that may be ameliorated by optical interconnect approaches. Serial access to memory slows processing, causing what has come to be known as the Von Neumann bottleneck; parallel access capability promised by optical approaches may alleviate this constriction. Concepts to incorporate the extremely wide bandwidth capacity of the optical carrier may enhance the capability of future switching and processing computational machines. System-oriented efforts comprise matching computing architectures to these optical capabilities. Several architectural issues are presently being investigated. Optical interconnects contribute to communication between electronic processors. Optical technologies provide the capacity for random, space-variant interconnects with fan-in and fan-out capability. Optical and optoelectronic devices, organized into processing elements, perform digital computation functions. Optical access and storage physics in memory devices resolve capacity, latency, and access limitations. Processing in the spectral domain can perform data-packet routing, byte-parallel transmission, and functions of medium-scale integration complexity. A recently initiated program aspect applies both device and architectural capabilities to aero-optic diagnostics, image processing, and wavefront correction in aerodynamically turbulent environments. This research pursues the development of intensively parallel, adaptive, or fault-tolerant computing systems that will be used to alleviate Air Force problems in areas such as smart munitions, electronic warfare, and artificial intelligence.

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Quantum Electronic Solids

The components of this program involve materials that exhibit cooperative quantum electronic behavior, such as ferromagnets or superconductors, with the primary emphasis on the latter, and any conducting materials whose surfaces can be modified and observed through the use of scanning tunneling and related atomic-force microscopies. The program also deals with device concepts utilizing these materials for electromagnetic detection and signal processing in Air Force systems.

The materials aspects of the program are based on the fabrication, characterization, and electronic behavior of thin films, which can ultimately lead to the discovery of new and improved electronic circuit elements. The major thrust is in the area of superconductivity, with a strong effort already in progress to understand the mechanisms that give rise to this phenomenon in selected ceramics and to produce high-quality Josephson tunneling structures. Currently there is increasing interest in studies to find superconducting behavior in other families of materials, with the hope of discovering such behavior at ever-higher temperatures. Interest in magnetic thin films, while limited, is focused on structures that may ultimately prove useful for incorporation into microwave circuit elements.

A continuing interest in this program is the search for new device concepts that involve superconductive elements, either alone or in concert with semiconductors and normal metals. Such concepts may involve any type of superconductor—metallic low-temperature superconductors or ceramic high-temperature superconductors. Examples include flux-flow transistors, phase-locked Josephson-junction arrays, and any unique geometry that utilizes the electronic properties of the superconductive state.

A newer aspect of this program is the inclusion of scanning probe techniques to fabricate, characterize, and manipulate atomic, molecular, and nanometer-scale structures on substrates of technological interest. These techniques, such as scanning tunneling microscopy and scanning electrochemical microscopy, can be used to create new molecular entities that are expected to permit reliable control of the motion of a single electron and, in turn, to lead to a new generation of supersensitive electrometers and infrared detectors, and to the ultimate miniaturization of analog and digital circuitry.

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Semiconductor and Electromagnetic Materials

Air Force electronic and photonic signal processing, communications, surveillance, and electronic warfare systems require continual improvements in performance. This research program is directed toward developing advanced electronic, optoelectronic, and electro-optical materials to provide the required improvements in future Air Force electronic and photonic systems. In particular, we seek to generate the fundamental knowledge and the materials data base required for the growth and use of novel, as well as existing, electronic and photonic materials and structures. No single electronic material has the combination of properties required for all applications, so several classes of semiconductor materials, including a variety of heterostructural combinations, are currently under investigation. Similarly, several classes of photonic materials, including semiconductor heterostructures and nonlinear optical materials, are also under investigation.

Compound semiconductors such as gallium arsenide and indium phosphide, the ternary alloy gallium aluminum arsenide, and heterostructural combinations of such materials are the foundation of a whole new generation of ultra-high-speed, high-frequency digital and microwave devices. These materials provide the electronic and optoelectronic properties necessary for advanced information- and signal-processing applications and for optoelectronic communications. We are investigating the compound semiconductors for potential use in detectors for the ultraviolet to far-infrared region, in solid-state lasers, in display and emitter sources, and in infrared-active optoelectronic countermeasures. Material issues are being pursued in the III-V nitride, III-V antimonide, and III-V phosphide-based compound semiconductors.

An effort to develop a Group IV semiconductor—specifically, silicon-germanium and silicon-germanium-carbon heterostructure technology for next-generation digital computer, microwave, and optical sensor systems—has begun and will continue. Efforts continue to combine Group IV and Group III-V material, heterostructure technology with Group II-VI and Group III-V material for future device applications. Silicides continue to be of interest. Novel concepts are being explored in quantum transport and structures. Interface issues and understanding of equilibrium and non-equilibrium growth processes through modeling are also important in heterostructure technology. Interest exists in developing a high level of material integration using selective-area epitaxy and growth on patterned or non-planar substrates. Our overall emphasis is to combine materials science with solid-state physics to investigate the fundamental aspects of growth, defects, and properties of multilayer semiconductor structures. Numerous oppor-

tunities remain to be explored in the area of heteroepitaxy of dissimilar materials and the bulk growth of nonlinear-optical and semiconductor materials that will continue to have a substantial impact on electronics, optoelectronics, and electro-optics.

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Photonic Physics

Research in this subarea seeks new ideas, knowledge, and insights in broad aspects of photonics. Semiconductor laser arrays are being investigated as research support to ongoing Air Force development programs, with increasing emphasis expected on wavelengths in the mid-infrared (2-5 micrometers). Very-low-noise, very-low-threshold semiconductor lasers, and widely tunable lasers, are being pursued for applications in communications and information processing. Fundamental semiconductor laser physics and laser modeling are being studied in support of device efforts. Ultrafast optoelectronic techniques are being studied for application in C3I systems—for example, ultra-high-speed communications networks and optically controlled radar systems. Ultrafast optoelectronic techniques are also being investigated to dramatically advance the speeds and available power of electronic circuits. Picosecond and femtosecond optical pulses are being studied to generate very-wide-band signals and to control and test electronic circuits at frequencies into the millimeter-wave range and far beyond into the terahertz range. Optical interconnect techniques are being investigated for application, especially to millimeter-wave circuit interconnections. Optoelectronic generation of very-high-power terahertz pulses is being studied, which could significantly contribute to so-called impulse radar systems. Very-wide-band, mode-locked semiconductor lasers are being devised and investigated as important devices in their own right, as well as for practical implementations of ultra-high-speed electronic studies. Directed energy beams, particularly laser beams, are being explored in a wide variety of direct-write materials-processing techniques, which offer broad and extremely important new capabilities, particularly in microelectronics fabrication and packaging. The use of such techniques for the fabrication of microelectromechanical devices is being studied.

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Optics

Research in this subarea concentrates primarily on optically pumped solid-state lasers, nonlinear and adaptive optics, and a variety of novel optical techniques. New, higher power, higher efficiency, compact, frequency-selectable or tunable lasers are being studied, especially semiconductor-pumped solid-state lasers. Upconversion lasers, in the visible or ultraviolet, are being pursued, and mid-infrared wavelengths (2-5 micrometers) are of increasing interest. Nonlinear optical techniques, particularly two-wave and four-wave mixing techniques in photorefractive materials and four-wave mixing in Kerr media, are being investigated for a variety of novel, potentially important applications, such as optical beam combining and quality enhancement, image amplification, and novelty filtering. The physics and novel device applications of so-called phase-controlled materials are of interest and are being pursued. Other novel nonlinear optical materials are being investigated, including single-crystal optical fibers and the use of resonances in gases. The latter are made very attractive by recent capabilities to produce semiconductor diode lasers that are accurately tuned to the resonances. Gases embedded in "caged" solids are being studied. These materials could offer the benefits of resonances in gases at high pressure but in solid-state form. Novel, efficient means are being devised to convert the wavelength of existing lasers into new regimes important for applications. Nonlinear optical techniques are being extended to the millimeter-wave region, principally through the study of nonlinear transmission lines. New techniques are being developed in near-field optical microscopy, a field with revolutionary technological possibilities.

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X-Ray Physics

New concepts, with potentially revolutionary scientific and technological payoff, are being studied in the generation, control, and application of soft and hard x rays. Application studies include x-ray microscopy and microanalysis. Analytical techniques are being pursued in support of Air Force needs in nondestructive evaluation and flexible manufacturing. Imaging techniques are being investigated in the soft x-ray range for application to analysis and diagnostics of physical, electronic, and biomedical nanostructure systems. Generation studies include those aimed at x-ray lasers and laser-plasma-generated x rays, particularly femtosecond-pulse lasers. A multifaceted materials and analysis program in multi-layer x-ray mirrors is progressing to elucidate the physics

and how to control the interface roughness and material intermixing at layer boundaries. Major thrusts are to extend high reflectivities to shorter wavelengths and to coat curved (focusing) optics at high reflectivity. Studies are being undertaken for the understanding and development of a science and technology of nonlinear optics in the x-ray region. Theoretical and experimental studies are being supported with the general vision of building, over time, an x-ray technology as facile as today's optics technology.

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Atomic and Molecular Physics

This program involves experimental and theoretical research on the properties and interactions of atoms and molecules and forms the basic underpinning of a large range of technological applications in navigation, guidance, communications, atmospheric physics, low- and high-altitude nuclear weapons effects phenomenology, directed-energy weaponry, and lasing mechanisms.

Topics to be pursued include the following:

1. Trapping and cooling of atoms and ions for high-resolution spectroscopy and study of cold atom collisions.
2. Electronic, vibrational, and rotational energy levels, transitions, selection rules, spectra, and oscillator strengths; molecular structures and symmetries.
3. Theories and efficient methods of calculating atomic and molecular properties, orbitals, and wave functions (with emphasis on inclusion of electron correlation effects).
4. Ultraviolet emission cross sections of atmospheric species.
5. Interactions of atoms in strong electric, magnetic, and radiation fields.
6. Advanced energy sources and efficient energy-conversion technology. The principal interest here is the study of antimatter. Problem areas include understanding basic properties, cooling antiprotons, storing condensed antimatter, controlled containment and conversion of annihilation energy, and more efficient production of antimatter.

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Plasma Physics

We are seeking innovative approaches for exploring novel concepts that exploit the collective interactions

of charged particles with electromagnetic fields.

Our primary areas of interest include the following:

1. Electron-beam-driven sources of microwave and millimeter-wave radiation.
2. Microwave interactions with plasmas.
3. High-current charged-particle-beam accelerators.
4. Numerical simulation of plasma phenomena.
5. Plasma propulsion concepts for space platforms.
6. Energy-efficient methods to generate and maintain free electron densities of 10^{13} per cc in sea-level air.

Research proposals will also be entertained for funding under the Exploratory Concepts portion of the DOD/Tri-Service Vacuum Electronics Initiative. That program is seeking novel ideas for military vacuum electronics systems that could be exploited by the U.S.

vacuum electronics industry. In addition to technical excellence, successful proposers under this initiative must also demonstrate strong university/industry ties. Proposed concepts must be sensitive to military constraints (i.e., low voltage, compact, lightweight, rugged, and energy efficient).

Other plasma research topics will be considered on a case-by-case basis. However, in general, this program is not interested in dense (strongly coupled) plasmas nor in space plasmas.

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LIFE AND ENVIRONMENTAL SCIENCES

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The Directorate of Life and Environmental Sciences supports basic research in a number of areas of high interest to the Air Force. In addition to extramural grants, complementary basic research programs related to these areas are supported in Air Force laboratories. The Armstrong Laboratory, headquartered at Brooks Air Force Base in San Antonio, Texas, is the primary laboratory for life-sciences-related research. The primary laboratory for terrestrial, atmospheric, and space sciences research is the Geophysics Directorate of the Phillips Laboratory located at Hanscom Air Force Base, Massachusetts. Many opportunities exist for collaborative research between academic scientists and Air Force laboratory scientists. Further information on these opportunities can be obtained from the program managers listed in this section.

Neuroscience

This program supports basic research on the neurobiology of behavior. The ultimate objective is to understand the neural mechanisms that determine the effectiveness of skilled, healthy persons performing demanding mental and physical tasks. Areas of emphasis are fundamental studies of the neurobiological mechanisms underlying neuronal responsiveness, learning and memory, fatigue, stress, attention, and arousal.

A strong focus is on the psychobiology of stress. We encourage studies to determine the neurochemical and behavioral consequences of stress and how to regulate the stress response.

We give high priority to investigations that rigorously examine the behavioral consequences of neurochemical regulation. We accept proposals for neurobiological research that does not study behavior but that would clearly further understanding of behavior. We rarely support applied studies of human performance.

In conjunction with other programs described in this pamphlet, the neuroscience program may support neurobiological research on visual and auditory information processing, multisensory integration, and higher cognitive functions.

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Chronobiology

The objective of the chronobiology program is to elucidate the biological mechanisms responsible for circadian rhythmicity and how they influence behavior relevant to skilled human performance. We seek proposals on the location and function of circadian pacemakers; mechanisms by which pacemakers such as

the suprachiasmatic nucleus are entrained or reset; and the sensory, motor, and cognitive manifestations of circadian activity. Experimental approaches involving lesion studies, neurochemistry, molecular biology, neurophysiology, pharmacology, and behavior will address how the circadian timing system is regulated. Studies with vertebrates are of most interest. Reproductive studies will not be considered.

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Perception and Recognition

This program supports visual and auditory theory, modeling, and psychophysical research on human adults. The primary objective is to discover and quantitatively model featural processing mechanisms underlying sensory pattern perception and recognition. We encourage multidisciplinary research, particularly if the results can be constrained by behavioral data. Collaboration between psychophysicists and scientists in other disciplines is often valuable. Theoretical efforts are most welcome.

The program currently supports theoretical and experimental work on topics related to featural processing and pattern classification, including the visual mechanisms of contrast detection and discrimination, motion, eye movements, color, and stereopsis, as well as auditory mechanisms that underlie recognition, localization, and speech.

We also support theory and modeling of neural circuitry in the sensory and sensorimotor pathways of biological systems, primarily in higher vertebrates; multidisciplinary approaches, as well as models and simulations of the dynamic behavior of neuroanatomically distinct regions, are especially emphasized.

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Spatial Orientation

This program supports research focused on the accurate integration of the visual, visual-vestibular, visual otolith, and proprioceptors as they apply to the dynamic aviation environment including perceived location and movement through space. Research is especially encouraged to identify and model the sensory and sensorimotor mechanisms that process environmental cues from single and multiple sensory sources. Studies of the sub-, trans-, and suprathreshold stimuli that influence the spatial orientation process are encouraged. We will

consider both theoretical and experimental work.

Theoretical approaches may include analytic and computational models that attempt to explain performance, preferably in terms of underlying neural processes. Experimental approaches may include human or animal studies, but those leading more directly to models of human performance will be emphasized.

Proposals are considered for work on the following and other related topics: visual vision, visual orientation and posture, auditory cues, vestibular and proprioceptive perception of movement, multisensory integrative mechanisms, simple sensorimotor behaviors (e.g., ballistic movement), and adaptation.

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Cognition

This program supports basic research on cognitive processes of individual and small teams, particularly the performance-related aspects of attention, memory, information processing, learning, reasoning, problem solving, and decision making under stress. The study of these topics under conditions of high workload in training environments or in team situations is especially welcome.

The goal of the program is to support theoretical and experimental research that illuminates the fundamental mechanisms underlying human performance. We support research using behavioral methods alone or a combination of behavioral and biological or computational methods.

Three special programs provide for collaboration with Air Force laboratory scientists:

1. *Center for Learning Ability*

This effort provides awards for collaboration with scientists at the Armstrong Laboratory outside San Antonio, Texas, a large test facility for research on individual differences in cognitive ability. This unique facility includes 30 test stations with microcomputers and associated equipment and a mainframe computer for reducing data. Several hundred new subjects are available for testing each week. One current research project measures individual differences in processing speed and working memory capacity to predict learning performance. Proposers are encouraged to describe other studies related to individual differences in learning ability. Awards will support visits to this facility for collaborative research.

2. *Intelligent Teaching*

This program supports collaboration with scientists at the Armstrong Laboratory to develop theory-based automated instructional techniques. A laboratory of flexible microcomputer-based training delivery systems

is available for investigations of training strategies using large samples of subjects.

3. This effort provides access to facilities for team research at the Armstrong Laboratory. Collaborative research and modeling of distributed team decision making and performance is appropriate.

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Bioenvironmental Sciences

Air Force operations utilize chemical and physical agents that are potentially harmful to Air Force personnel, the surrounding populace, and the environment. These agents include fuel components, lubricants, solvents, heavy metals, and aerospace materials. (A list of chemicals is available on request.) Furthermore, these materials may be contained in waste streams on Air Force installations or as contaminating compounds in ground water and soil. To protect humans and the environment and to facilitate the cleanup of contaminated sites, the Air Force supports basic research efforts in understanding the effects of toxic agents on biological systems, the mechanisms of toxicity, and the ability of micro-organisms to degrade and detoxify hazardous chemicals. We support fundamental research on Air Force hazardous agents in areas of predictive and environmental toxicology and bioremediation.

The following topics represent basic research interests of the Air Force's program in Bioenvironmental Science:

1. *Predictive Toxicology*

- a. Cellular/molecular mechanisms of toxicity.
- b. In vitro structure-activity relationships and their quantitative and predictive implications.
- c. Biologic markers of toxicity and metabolism.
- d. Pharmacokinetic modeling of toxic Air Force chemicals.

2. *Environmental Toxicology*

- a. Toxic effects of chemicals on organisms and the resultant ecological stress.
- b. Predicting effects of chemical mixtures on ecological systems.
- c. Mechanisms of metabolic activation of chemicals in the environment.
- d. Biologic markers of environmental toxicity.

3. *Bioremediation*

- a. Novel microbial metabolic pathways (anaerobic and aerobic) and the removal/degradation of metals and chemicals, including nitrogen-containing propellants.
- b. Modification of metabolic pathways, co-metabolism, and enhanced biodegradation.

- c. Improving biodegradation techniques via gene manipulation.
- d. Role of ecological niches and biotic inter-relationships in optimizing degradative potential.

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Terrestrial Sciences

The purpose of this research is to increase our understanding of solid earth dynamics, structure, and processes that may impact Air Force operations. Fundamental investigations in seismology, geodesy, and gravity are required that will broadly contribute to mitigating nuclear weapon proliferation and to evolving next-generation navigation and precision-positioning concepts.

The main emphasis of seismic research is improved understanding of wave-propagation characteristics and discrimination methodologies, including evasion techniques, in regions where nuclear weapons might be under development. We want to improve detection thresholds, enhance discrimination by location, improve the capability to estimate yields of isolated shots detonated in nonstandard environments, and resolve the basic paradox between observing earthquakes and explosions. Some topical examples are source-depth and near-source-structure effects on excitation of regional phases; empirical descriptions of seismic records generated by earthquakes and explosions from the same source region; determining source depth from depth phases in various geological provinces; seismic coupling as a function of rock type; and regional phase propagation, attenuation, and scattering in complex three-dimensional structures.

Basic research in geodesy has the goal of establishing inertial system concepts for ultraprecise, nonjamming, fully autonomous navigation. Real-time gravity compensation research is required so that aircraft, spacecraft, and tactical munitions can be guided autonomously. Precise gravity field modeling involves geopotential coefficient estimation, upward-continuation and downward-continuation studies, and new inertial and Global Positioning System (GPS) measurement approaches.

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Meteorology

A fundamental understanding of the physics underlying weather and climate is essential for improving our capability to support strategic and tactical military readiness.

We are interested in innovative research proposals that seek to illuminate the dynamic distribution of energy among large, medium, and small scales of atmospheric motion and the nature of relationships between cloud processes and large motion scales. While we recognize that measurements and measurement techniques are important in the research, we currently place a higher priority on efforts to extract the underlying physics rather than proposals that concentrate on gathering data.

We assign highest priority to research ideas in mesoscale dynamics and predictions; physics and dynamics of precipitation systems; cloud microphysics; boundary layer dynamics; atmospheric electricity; and satellite and radar meteorology, including the development of new remote measurement techniques and analytical techniques for extracting meteorological data.

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Ionospheric Sciences

Our research goal is to define the physical and chemical properties of the Earth's upper atmosphere and ionosphere and to determine effects of these properties on Air Force systems operating in or through these regions.

Our main interests are understanding the structure and chemistry of the upper atmosphere and the physics and dynamics of the ionospheric region. This effort includes modeling atmospheric tides, solar radiation, high-energy particles, magnetospheric disturbances and their effects on ionospheric dynamics, and electron density structure.

While we recognize that measurements and measurement techniques play an important role in this area, we are convinced that significant progress will require programs that carefully combine theory with experiment. In the near term, we will emphasize analyzing information to extract the fundamental physics rather than gathering data. We place the highest priorities on research in ionospheric disturbances; ionospheric physics; plasma turbulence and dynamics; ionospheric-magnetospheric coupling; and ion/neutral structure, chemistry, and transport mechanisms.

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Optical and Infrared Environment

Research is directed toward understanding the atmospheric processes that could influence design and operation of communication, navigation, surveillance, and weapons systems operating in the optical and infrared to millimeter wavelengths.

Our interest centers on creative research leading to new knowledge of the physical processes controlling optical and infrared emissions in the quiescent atmosphere and of processes caused by natural auroral activity.

Our highest priorities are research ideas in auroral backgrounds, atmospheric transmission and absorption, natural airglow, and optical aerosols. Other topics of interest include remote sensing of atmospheric quantities, theoretical studies of molecular parameters, and coherence effects in spectroscopy.

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Space Sciences

The effects of electromagnetic radiation, charged atomic particles, and electric and magnetic fields can endanger the mission and degrade the performance of Air Force systems operating in near-Earth space. Both the ambient and the disturbed space environment can disrupt the detection and tracking of missiles and satellites, distort communications, and interfere with surveillance operations.

This research provides basic knowledge of the space environment for the design and calibration of Air

Force systems operating in and through space. Experimental and theoretical methods are used to study the following:

1. Solar activity.

2. Solar outbursts and their travel from the Sun to the Earth.

3. The particle and field composition of the space environment, especially the magnetosphere.

4. Changes in this environment caused by natural and artificial disturbances.

5. The response of spacecraft systems and operations to conditions in space.

6. The celestial background and its temporal, spatial, and spectral variations.

Current topics of interest include the following:

1. Developing a capability to forecast solar activity—for example, by identifying phenomena on the Sun and in interplanetary space that are associated with perturbations of the aerospace environment.

2. Investigating the production and transport of magnetospheric plasma to understand geomagnetic storm phenomena and to predict the expected charged-particle distributions encountered by Air Force spacecraft.

3. Developing models to simulate wave modes generated during injection of artificial beams into space plasmas.

4. Understanding celestial background radiation and developing novel techniques to improve space surveillance systems.

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MATHEMATICAL AND COMPUTER SCIENCES

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The Directorate of Mathematical and Computer Sciences sponsors extramural research programs in the areas described in this section. In addition, the Air Force laboratories perform complementary in-house basic research in specific areas. For example, the Wright Laboratory (at Wright-Patterson Air Force Base, Ohio, and at Eglin Air Force Base, Florida) and the Phillips Laboratory (at Edwards Air Force Base, California) engage in basic research in guidance and control. The Phillips Laboratory (at Kirtland Air Force Base, New Mexico, and Hanscom Air Force Base, Massachusetts) performs basic research in computational mathematics and parallel processing. The Wright Laboratory at Wright-Patterson Air Force Base also engages in basic research in electronic prototyping, neural networks, sensor fusion, and dynamical systems. The Rome Laboratory at Griffiss Air Force Base, New York, performs basic research in signal processing and software and systems, and at Hanscom Air Force Base it performs basic research in electromagnetics. The Phillips Laboratory at Kirtland Air Force Base, New Mexico, performs basic research in imaging.

Dynamics and Control

Research in this program leads to improved techniques in the design and analysis of new control systems with enhanced capabilities and performance for use in future Air Force missions. Applications include the development of robust feedback controllers for advanced high-performance aircraft and adaptive, reconfigurable flight control systems; control of vibrations and the shape of large, flexible space structures; active control of wing camber using embedded smart sensors and actuators; control of combustion and fluid flow processes associated with aerospace vehicles; control of electromagnetic radiation by controlling the properties of a propagating surface; and novel hierarchical control systems that can intelligently manage actuator, sensor, and processor communications in complex systems. We emphasize research in distributed-parameter control (including control of complex coupled fluid/structure systems); robust, adaptive multivariable feedback control for both linear and nonlinear systems; and, to a lesser degree, fundamental applied research in stochastic control, design optimization, control of discrete event dynamical systems, and use of neural networks for control design.

Research in robust multivariable feedback control will develop mathematical methods that allow the design and analysis of feedback systems that achieve stability and satisfy other performance objectives in the face of model uncertainties. There is special interest in the development of a theory of robust control for nonlinear and distributed-parameter systems and in novel approaches to effective robust-control-oriented system identification techniques.

Distributed-parameter control problems involve systems with dynamics given by partial differential equations, integro-differential equations, or equations with delays. New integrated approaches are needed to develop approximation techniques for the identification, control, and optimization of distributed-parameter systems. While efforts continue in dynamics and control theory for flexible structures, increased attention is focused on mathematical techniques that support the development of modern control theory applicable to controlling fluid flow and combustion processes, as well as complex, highly nonlinear coupled interactions between structural deformation and unsteady flows. These research efforts are coordinated with ongoing efforts in aerospace engineering that emphasize experimental research.

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Physical Mathematics and Applied Analysis

This program pursues mathematical models and their analysis in areas of interest to the Air Force. Our goal is to distill focused mathematical models of particular physical phenomena and the mathematical methods for their analysis, as well as to produce models sufficient for numerical computation. The payoffs include understanding and modeling physical phenomena such as nonlinear optics or turbulent flow, leading to methods for their simulation and control.

While supporting a broad range of topics, this program concentrates on several special interests: nonlinear optics, inverse problems (the radar interpretation problem and nondestructive evaluation), mathematical materials science, and theoretical fluid mechanics (including hypersonics). All of these areas have in common the nonlinearity of their mathematical descriptions. Nonlinear mathematics exhibits a spectrum of behavior for which effective mathematical understanding either is unavailable or is only beginning to emerge. What is striking is the ubiquitous appearance of coherent structures (solitons and their relatives), chaotic solutions, or formation of singularities in many seemingly disparate physical scenarios. Research emphasizes both analytical and numerical tools that tackle these problems.

One goal of nonlinear optics is the effective exploitation of lasers. Solitons, chaos, and other operational possibilities that affect beam control, imaging, and diode array stability are stressed. Research on laser-induced ocular damage involves identification of field filamentation and incipient singularity formation.

Recent work in mathematical materials science involves a blend of nonconvex energy integrands and modern variational approaches that attempt to incorporate

measure theory and homogenization in a computationally useful way. The inverse-problems area seeks, for example, to deduce the nature of the scatterer from the waves it scatters back to the observer. The emphasis here is to confront scenarios in which the Born approximation and its obvious extensions are inapplicable.

Research in hypersonics could seek to include real gas effects and rarefied flow regimes. Nonlinear stability, important distinguished limits, and clarification of unresolved issues in noncontinuum models are some areas of interest.

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Computational Mathematics

This program aims to develop improved mathematical methods and algorithms to utilize advanced computational capabilities to support the scientific computing interests of the Air Force. For the most part, this effort concentrates on supporting the development of innovative methods and algorithms that enable the improved modeling, simulation, understanding, and control of complex physical phenomena of interest to the Air Force. These phenomena include fluid flow, combustion processes, control of flexible space structures, nonlinear optics, directed energy weapons, high-energy-density materials, crystal growth, weather modeling, high-power microwaves, and electromagnetic pulse source output. Our research also supports the national agenda in high-performance computing.

We are developing numerical methods and algorithms to fully exploit the potential of parallel computing for fast, accurate numerical solution of complex systems occurring both in engineering design of Air Force systems and in operations. Efficient use of available parallel machines requires that we pay increased attention to dynamic resource allocation and load balancing, domain decomposition techniques, scalable parallel algorithms, adaptive meshing for shock tracking, and parallel schemes for adaptive grid generation. As the cost of hardware continues to decrease, the results of this program may affect the design of specialized architectures for solving critical scientific problems.

Typically the computational models in this program rely on some numerical scheme that implements a discretization of continuum mechanics equations—generally partial differential equations—that represent the physics of the situation. However, alternative computational models may be appropriate for many problems. We are investigating both traditional and radical approaches in this program. We are developing and improving a variety of numerical methods in this subarea, including

homogenization techniques, continuation methods, finite elements, particle and vortex methods, finite difference methods, essentially nonoscillatory methods (ENO), and spectral methods. In addition, fast, accurate, and robust methods for solving large systems of linear equations lie at the heart of many scientific computing problems of interest to the Air Force. For this reason, computational linear algebra, especially multilevel or multigrid techniques, continues to receive attention. This emphasis is, however, diminishing.

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Optimization and Discrete Mathematics

Our goal is to develop mathematical methods for solving large or complex problems, such as those occurring in logistics, engineering design, or strategic planning. These problems can often be formulated as mathematical programs. Therefore, research is directed at linear and nonlinear programming methods, especially those that can be implemented on parallel computers. We are also emphasizing discrete structures, as they often represent important Air Force problems.

Three areas of particular importance are emphasized in discrete mathematics. First is the optimal solution of integer programming models and other combinatorially based structures. These structures arise in areas of interest to the Air Force, such as design of very-large-scale integrated (VLSI) networks, frequency assignment, and scheduling and routing. Second, in addition to the evolution of traditional solution methods, the program supports new algorithmic paradigms such as simulated annealing and genetic algorithms. Third, we support research in computational geometry, especially as it relates to electronic prototyping.

Research in optimization focuses on the development of special algorithms for the particular structures that arise, emphasizing implementation on parallel architectures. Since networks are so important for military logistics problems, optimization over networks is a major component of our program. Some research on stochastic optimization, which will benefit from increased parallelism, will begin, as will research on the use of nonlinear programming for the optimization of polymers and biomolecules.

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Signal Processing, Probability, and Statistics

This research activity is aimed at the foundations and applications of data collection and interpretation. Digital-based and analog processing of signals is an aspect of special significance to the Air Force. Much of the data available for tracking and reconnaissance and for surveillance and communications is carried by an electromagnetic medium. Modern radar, infrared, and other electro-optical sensing systems interpret and act on data that is obtained in massive quantities from multiple sources. Statistical research into spatial and temporal dependencies and their effects will be undertaken to minimize the cost and complexity of fulfilling this essential function.

The Air Force faces a general need for support in analyzing and interpreting data for logistical and personnel management. Reliability-analysis techniques are pivotal in ensuring that complex Air Force systems are dependable. Research into statistical methods will support more accurate modeling of the behavior of components and entire systems and is necessary for the development of effective maintenance strategies. Concepts leading to more realistic and robust models, involving dependent components or imperfect repair, are essential to a system integration capability and will receive emphasis.

In signal processing, some outstanding issues are how to develop robust algorithms for data compression, image reconstruction, and spectrum estimation in the presence of noise. Characterization of non-Gaussian environments is of special interest, with applications to the key areas of high-speed data communications and enhanced image processing. We will give high priority to investigation of innovative mathematical tools such as "wavelet" and related transforms, with a view toward their potential in detecting transient phenomena in noisy signals, synthesizing hard-to-intercept communications links, achieving high rates of data and image compression, and rapidly performing discrimination and identification on features of interest.

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Software and Systems

The goal of this research effort is to develop advanced information-processing capabilities needed to support future Air Force needs in areas such as command, control, communications, and intelligence (C3I), avionics, logistics, and engineering design. The primary research emphasis is on software. Research focuses on

scientific methods of improving the software engineering process and methods of exploiting distributed hardware. The goal is improved performance for complex Air Force applications on future hardware.

Achievement of these goals currently has two principle thrusts: (1) formal methods in software engineering and (2) distributed computing. Formal methods involve the use of mathematics and logic as the primary element of software engineering. The process begins in the specification stage. The desired product is specified using mathematical and logical notation that provides two key advantages: First, the specifications can be checked for consistency and harmony; second, a form of "supercompiler" can generate code either automatically or semi-automatically from the specifications.

As the Air Force, and the entire military, grow into a more interconnected environment, forces will seek more effective ways of sharing information and resources. Improved tools will be needed to harness the power of distributed processors for analyzing the increasing flow of data from advanced (perhaps physically distributed) sensor systems. In particular, a major thrust has been established in distributed computing for C3I. The objective is to enable the confident construction (design and implementation) and maintenance (evolution and upgrading) of distributed, heterogeneous computing systems for C3I. These critical systems continue to pose research challenges in meeting the simultaneous constraints of real-time (or deadline-driven) response, fault tolerance including survivability, and security in stochastic environments.

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Artificial Intelligence

Research within this program includes the fundamental building blocks of artificial intelligence: knowledge representation and computer-based reasoning. Applications areas of interest include machine vision and intelligent teaching.

A critical Air Force requirement is automatic reasoning methods to support rapid decision making under conditions of high information loading with conflicting and complex data. Research efforts directed toward real time decision making, reasoning under uncertainty, and management of incomplete or unreliable information are sought.

The Air Force needs improved capabilities in coordinating distributed automated systems, especially automated planners and schedulers. Research efforts are being supported to develop a theory to support the design and control of distributed intelligent agents.

Image-understanding vision is important for many Air Force applications such as surveillance, target identification, object recognition, and cartography. Research in image understanding of scenes from sensors using the visual and nonvisual bands of the electromagnetic spectrum includes both model- and physics-based approaches and the application of geometrical and algebraic invariant theories in image recognition.

Intelligent teaching for understanding, operating, and maintaining complex systems is an area of increased Air Force interest. Adaptive teaching systems and advanced presentation methodologies are two areas of research interest to this directorate. Cognitive aspects of intelligent teaching are being supported within the Environmental and Life Sciences Directorate.

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Neural Computation Systems

This program focuses on building brainlike computers that are applicable to smart munitions, pilot assistance, surveillance, high-agility robotics, and intelligent logistics. The research uses biological principles of signal processing and organization to perform computation. Neural processing models offer a significant opportunity to exploit new kinds of highly parallel very-large-scale integrated (VLSI) hardware that will be made possible by wafer-scale integration, nanoelectronics, and superconducting circuits. Neural circuits consist of a large number (potentially millions) of simple neuronlike processors placed together in complex networks. These networks can be trained to model relationships based on experience, and they can generalize upon this experience to handle novel situations.

The program has three basic thrusts. First, it characterizes neural learning in order to improve training and generalization ability. As such, the program seeks to develop engineering discipline for selection of algorithms, sizing of networks, and prediction of test validity. The second thrust is to develop and analyze models of

learning from interaction with environments. In this scenario, the networks are not given data, but must find their own training data through an exploratory process. These techniques are particularly useful for control and active sensing. A new research initiative will focus on the use of such training techniques for control of phased-array radar and other adaptive beam-forming problems. The third thrust of the program involves the use of systems of coupled oscillators to perform computation. In this activity, the program seeks a better understanding of how best to learn complex temporal functions incorporating concepts of state, causality, and binding. Ultimately, these technologies are targeted for implementation in hardware systems that can learn from examples and compute at very high speed.

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Electromagnetics

This program focuses on state-of-the-art antenna systems for communications, radar, and propagation. Basic electromagnetic radiator research focuses on improvements in efficiency, radiation pattern control, effective bandwidth, impedance matching, radar cross section, and propagation through dispersive and random media. Unconventional propagation research focuses on radio wave propagation through ionospheric media such as high-frequency ducts. This research is also concerned with the use of particle beams to generate high-frequency waves for use in communication. Scattering research seeks to characterize and exploit the radar cross-section characteristics of both targets and terrain. Future research may also include models for the control of adaptive nonperiodically spaced phased arrays and three-dimensional algorithms for scattering by large objects.

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Academic Support Programs

United States Air Force/National Research Council Resident Research Associateship (USAF/NRC-RRA) Program

The USAF/NRC-RRA Program offers postdoctoral scientists and engineers opportunities to perform research at sponsoring Air Force laboratories. The objectives of the program are (1) to provide researchers of unusual promise and ability opportunities to solve problems, largely of their own choice, that are compatible with the interests of the sponsoring laboratories and (2) to contribute to the overall efforts of the Federal laboratories.

Postdoctoral Research Associateships are awarded to U.S. citizens and permanent residents who have held doctorates for less than 2 years at the time of application. They are made initially for 1 year.

Visiting Fellow Research Associateships are awarded to individuals who have held a doctorate for 5 or more years; U.S. citizenship is not a requirement. Successful applicants will have significant research experience and be recognized internationally as experts in their specialized fields, as evidenced by numerous publications in reviewed journals, invited presentations, authorship of books or book chapters, professional society awards of international stature, etc. Although awards to Visiting Fellow Associates are usually for 1 year, awards for periods of 3 months or longer will be considered.

Associates receive a stipend from the NRC while carrying out their proposed research. The 1993 annual stipend for a Postdoctoral Associate is \$39,000 with additional increments for each year past the Ph.D. An appropriately higher stipend is offered to Visiting Fellow Associates.

Awardees also receive a relocation reimbursement and funds for limited professional travel, if the research adviser recommends the travel and the NRC approves it in advance. Funding is normally provided for approximately 36 associates each year.

For additional information, contact—

Associateship Programs (GR430-A)
National Research Council
2101 Constitution Avenue, NW
Washington, DC 20418
(202) 334-2760

University Resident Research Program (URRP)

The URRP enables highly qualified university faculty members to spend 1 year, or 2 years with an extension, at Air Force laboratories working on research problems of interest to the Air Force. Through this program faculty members can use their expertise to contribute fresh ideas to Air Force research. AFOSR funds and manages the program. Air Force Laboratories furnish

the necessary support services, facilities, and equipment for the research. This program is limited to U.S. citizens.

Assignments are for 1 year unless the needs of the Air Force require an extension. The Air Force, the faculty member, and the university must agree to the extension, which will not exceed 1 year.

Participants continue to receive salaries from their universities. AFOSR and the Air Force laboratories negotiate with the university for travel and moving expenses and the amount of the salary needed to cover the time of the sabbatical or leave of absence. AFOSR provides the funds to the Air Force laboratory at which the research is done. The laboratory then reimburses the university for the assignee's salary and for the university's contribution to basic fringe benefits, such as health and life insurance, retirement, and Social Security. Cost sharing on the part of the university is encouraged.

An endorsement from the laboratory chief scientist is required before a candidate's application can be reviewed at AFOSR. Appointees have the status of visiting scientists or engineers in the laboratory and are subject to the general conditions of the laboratory. The date on which appointments begin, which may be any time during the year, is negotiated with the appointees.

For more information, contact—

URRP, Program Manager
AFOSR/NI
110 Duncan Avenue, Suite B115
Bolling AFB, DC 20332-0001
(202) 767-5013; DSN: 297-5013
FAX: (202) 767-5012

Summer Faculty Research Program (SFRP)

The SFRP provides research opportunities for qualified faculty members of U.S. colleges and universities at Air Force research facilities within the continental United States. The objectives of SFRP are to:

1. develop the basis for continuing research of interest to the Air Force at the faculty member's institution;
2. stimulate continuing relations among faculty members and their professional peers in the Air Force; and
3. enhance the research interests and capabilities of educators in scientific/engineering areas of interest to the Air Force.

University faculty members spend 8 to 12 weeks during the summer working at an Air Force research activity. To qualify, applicants must:

1. be U.S. citizens or permanent residents;
2. be faculty members of an accredited U.S. college, university, or technical institute; and
3. have at least 2 years of teaching and/or research experience.

After completing this program, participants may submit a proposal for continuing research at their own facilities. Selected proposals are funded under the Summer Research Extension Program (SREP).

For regular summer appointments, the research is conducted for a continuous period of 8 to 12 weeks between 1 April and 30 September; the start date is flexible. Under exceptional circumstances, AFOSR, a Summer Faculty Researcher, and the Air Force laboratory may arrange a research appointment during October through March.

For the research period, each Fellow receives about \$745 a week, an expense allowance of about \$50 a day, and a travel allowance to cover the cost of traveling to and from the Air Force research site. AFOSR Fellows may visit the research sites before the research period by writing the laboratory representative ahead of time.

For more information, contact—

Summer Programs Manager
AFOSR/NI
110 Duncan Avenue, Suite B115
Bolling AFB, DC 20332-0001
(202) 767-4970
FAX: (202) 767-5012

Summer Faculty Research Program/ Summer Research Extension Program (SFRP/SREP)

After completing the SFRP, participants may submit proposals to continue the research at their universities. These proposals, if accepted, are funded under the SREP. To compete for a SREP award, SFRP participants must submit a complete proposal and proposed budget either during or promptly after their SFRP appointment.

Each proposal is evaluated for technical excellence, with special emphasis on relevance to continuation of the SFRP effort as determined by the Air Force laboratory or center.

The maximum award under the SFRP/SREP is \$25,000 plus the amount shared by the employing institution. Employing institutions are encouraged to cost-share because the SREP is designed only to initiate research. The total available funds limit the number of awards.

Proposal deadline is 1 November. Funded projects start no earlier than 1 September and end no later than 15 December of the following year.

For more information, contact—

Summer Programs Manager
AFOSR/NI
110 Duncan Avenue, Suite B115
Bolling AFB, DC 20332-0001
(202) 767-4970
FAX: (202) 767-5012

Graduate Student Research Program (GSRP)

GSRP is an adjunct effort of the SFRP. The program provides research funds for selected graduate students to work at appropriate Air Force facilities with supervising professors who hold an SFRP appointment or with designated laboratory researchers. The objectives of GSRP are to:

1. provide a productive means for a graduate student to participate in research under the direction of a faculty member or researcher at an Air Force laboratory;
2. stimulate continuing professional association among graduate students, their supervising professors, and professional peers in the Air Force; and
3. expose graduate students to potential thesis topics in areas of interest to the Air Force.

To qualify as a Graduate Researcher in GSRP, applicants must be:

1. U.S. citizens;
2. holders of either a B.S. or an M.S. degree in the appropriate technical specialty;
3. registered in a graduate school program working toward an appropriate graduate degree at their respective institutions; and
4. willing to pursue their summer research work under the direction of a supervising professor who holds an appointment under SFRP or a designated Air Force laboratory researcher.

The research is conducted for a continuous period of 8 to 12 weeks between 1 April and 30 September. The student's research period should coincide with the appointment time of the supervising professor.

A selectee receives a predetermined stipend based on educational level. Holders of a B.S. degree receive about \$395 per week; holders of an M.S. degree receive about \$455 per week. In addition, a daily expense allowance of about \$35 is paid for each day the researcher spends at the Air Force location. A travel allowance is also included to cover the cost of traveling to and from the Air Force research site.

For more information, contact—

Research and Development Laboratories
Summer Research Program Officer
5800 Uplander Way
Culver City, CA 90230-6608
(800) 677-1363
or

Summer Programs Manager
AFOSR/NI
110 Duncan Avenue, Suite B115
Bolling AFB, DC 20332-0001
(202) 767-4970
FAX: (202) 767-5012

Laboratory Graduate Fellowship Program (LGFP)

As a means of increasing the number of U.S. citizens obtaining Ph.D. degrees in science and engineering, AFOSR annually offers about twenty-five 3-year fellowships. These fellowships are for study and research in areas of interest to the Air Force. Fellowships are limited to U.S. citizens who have received their baccalaureate degrees. Air Force laboratory graduate fellowships are tenable at any U.S. institution of higher education offering a Ph.D. in science or engineering.

Fellows receive stipends of \$15,000 the first year, \$16,000 the second year, and \$17,000 the third year. Stipends are prorated for fellowship periods of less than 12 months; however, the duration of the fellowship will not be less than 9 months. In addition to the stipend, the Air Force pays full tuition and fees to the Fellow's institution and provides \$2,000 per year to the Fellow's department.

Each Fellow is sponsored by an Air Force laboratory that assigns a mentor to the student. Fellows are required to perform research at their sponsoring Air Force laboratory for at least one summer period in their first or second year of the fellowship.

For more information, contact—

Southeastern Center for Electrical
Engineering Education (SCEEE)
1101 Massachusetts Avenue
St. Cloud, FL 34769

(407) 892-6146

or

Summer Programs Manager
AFOSR/NI
110 Duncan Avenue, Suite B115
Bolling AFB, DC 20332-0001
(202) 767-4970; DSN: 297-4970
FAX: (202) 767-5012

National Defense Science and Engineering Graduate (NDSEG) Fellowship Program

The NDSEG Fellowship Program is a Department of Defense (DOD) fellowship program sponsored by AFOSR, the Army Research Office, the Office of Naval Research, and the Advanced Research Projects Agency. The eligibility requirements and stipends paid, including tuition and fees, are the same as the LGFP. The DOD selects about 100 Fellows per year; the Air Force sponsors about 25 of the Fellows.

Ten percent of these awards will be set aside for applicants who are members of an ethnic minority group underrepresented in the advanced levels of the U.S. science and engineering personnel pool, i.e., American Indian, Black, Hispanic, Native Alaskan (Eskimo, Aleut),

or Native Pacific Islander (Polynesian or Micronesian).

Those Fellows selected and sponsored by the Air Force will be offered the opportunity to become associated with an Air Force laboratory but are not required to spend a summer at an Air Force laboratory.

For more information, contact—

NDSEG Fellowship Program

Battelle

200 Park Drive, Suite 211

P.O. Box 13444

Research Triangle Park, NC 27709

(919) 549-8505

or

NDSEG Fellowships

AFOSR/NI

110 Duncan Avenue, Suite B115

Bolling AFB, DC 20332-0001

(202) 767-4970

FAX: (202) 767-5012

Advanced Thermionic Research Initiative (ATRI)

ATRI's purpose is to advance the knowledge and technology necessary for realizing the next generation of microwave and millimeter-wave tubes. The approach consists of a multidisciplinary education and research program for new electrical engineers and scientists leading to an M.S. and/or Ph.D. degree.

This program, originally called Air Force Thermionic Engineering Research (AFTER), was begun in 1977 at Stanford University and then transferred to the University of Utah in 1981. Since fall 1987 the program has resided at the University of California-Los Angeles. Professor Neville C. Luhmann, Jr., Electrical Engineering Department, University of California-Los Angeles, heads the program. The program is cosponsored by Hughes Aircraft Co.; Litton Industries; Northrop Corp.; Teledyne MEC; Varian Associates, Inc.; and Stanford Linear Accelerator (SLAC).

Fellowships are available for graduate study and research in amounts up to \$20,000 per year.

U.S. citizens with B.S. degrees in electrical engineering may apply. Selection is subject to the admissions requirements of UCLA. Thesis topics are cleared through the ATRI Advisory Board, which consists of representatives from UCLA, industry, and the Air Force.

For more information, contact—

Professor N.C. Luhmann, Jr.

Attn: Lynette Lombardo

Electrical Engineering Department

University of California

Los Angeles, CA 90024-1594

(213) 825-3209

or

Mr. James Ryan
RL/ERSD
525 Brooks Road
Griffiss AFB, NY 13441-4505
(315) 330-4891; DSN: 587-4891



Proposal Guidance

AFOSR invites proposals for basic research in support of the Air Force Defense Research Sciences Program. The areas of interest are covered in Section II of this pamphlet.

Our overriding purpose in supporting this research is to advance the state of the art in those areas related to the technical problems the Air Force encounters in developing and maintaining a superior Air Force; in lowering the cost and improving the performance, maintainability, and supportability of Air Force weapon systems; and in creating and preventing technological surprise.

Proposals will be evaluated through a peer or scientific review process and selected for award on a competitive basis according to Public Law 98-369, Competition in Contracting Act of 1984, and 10 United States Code 2361. The primary evaluation factors are

1. The scientific and technical merits of the proposed research.
2. Potential contributions of the proposed research to the mission of the Air Force.
3. Availability of funds.

Additional evaluation criteria, almost as important, are as follows:

1. The likelihood of the proposed effort to develop new research capabilities and to broaden the research base in support of national defense.
2. The offeror's capabilities, related experience, facilities, techniques, or unique combinations of these factors that are integral to achieving the objectives.
3. The qualifications, capabilities, experience, and past research accomplishments of the proposed principal investigator, team leader, or key personnel who are critical to the mission.
4. Realism and reasonableness of proposed cost.
5. Offeror's record of past research accomplishments and past performance.

No further evaluation criteria will be used in source selection. The technical and cost information will be analyzed at the same time during the evaluation process.

Proposals may be submitted for one or more of the topics in Section II or for a specific portion of one topic. A proposer may submit separate proposals on different topics or different proposals on the same topic. The Government does not guarantee an award in each topic area.

The cost of preparing proposals in response to this announcement is not considered an allowable direct charge to any award made under this Broad Agency Announcement (BAA) or any other award. It may be, however, an allowable expense to the normal bid and proposal indirect cost specified in the Federal Acquisition Regulation (FAR) 31.205-18, or Office of Management and Budget Circular A-21 or A-122. Only contracting

officers are legally authorized to commit the Government to an award under this BAA.

Technology sharing and transfer is encouraged and in this respect AFOSR welcomes proposals that envision university/industry cooperation. Cooperation with or use of facilities in an Air Force laboratory is encouraged.

Every effort will be made to protect the confidentiality of the proposal and of any evaluations. The submitter must mark the proposal with a protective legend in accordance with FAR 52.215-12 (modified to permit release to outside evaluators retained by AFOSR, if protection is desired for proprietary or confidential information).

Proposals should briefly address whether the research proposed will result in environmental impacts outside the laboratory and how the proposer will ensure compliance with environmental statutes and regulations.

It is the Air Force policy to eliminate the use of Class I Ozone Depleting Substances (ODS) in all Air Force procurements. This policy implements Section 326 of the Fiscal Year 1993 Defense Authorization Act (Public Law 102-484). Unless a specific waiver has been authorized, Air Force procurements: (1) May not include any specification, standard, drawing or other document that requires the use of a Class I ODS in the design, manufacture, test, operation, or maintenance of any system, subsystem, item, component or process; (2) May not include any specification, standard, drawing or other document that establishes a requirement that can only be met by use of a Class I ODS; and (3) May not require the delivery of any item of supply that contains a Class I ODS or any service that includes the use of a Class I ODS. For the purpose of this policy, the following are Class I ODS (1) Halons: I2II, I3OI and 2402 (2) chlorofluorocarbons (CFC): CFC-11, CFC-12, CFC-13, CFC-111, CFC-112, CFC-113, CFC-114, CFC-115, CFC-211, CFC-212, CFC-213, CFC-214, CFC-215, CFC-216, and CFC-217. (3) Other controlled substances: carbon tetrachloride, methyl chloroform, and methyl bromide. Proposals submitted in response to this BAA will be reviewed by the Air Force to reflect this policy. Where considered essential, specified authorization will be obtained to use of these substances and these authorized uses will be identified in the resultant contract. Proposers must notify the Air Force if any Class I ODS will be required in the performance of a proposal submitted under this BAA.

Unnecessarily elaborate brochures or presentations beyond that sufficient to present a complete and effective proposal are not desired. Proposals must be submitted as hard copy.

For additional guidance on the form and content of proposals, proposers should refer to the AFOSR *Proposer's Guide* (AFOSR Pamphlet 70-11), which can be obtained by sending a self-addressed label with your request to:

AFOSR/XPT
110 Duncan Avenue, Suite B115
Bolling AFB, DC 20332-0001

These pamphlets may also be downloaded from the Federal Information Exchange (FEDIX), an on-line information system accessible via computer and modem. Call the FEDIX computer at (800) 783-3349 (eight data bits, one stop bit, no parity). There is no charge to the user for accessing the information. The FEDIX help line is available at (301) 975-0103 from 8:30 a.m. until 5:00 p.m. e.s.t.

Proposals may be submitted at any time to the appropriate AFOSR program manager or directorate (addresses are found in Section II). There will be no further

solicitations. Historically Black Colleges and Universities (HBCUs) and minority institutions (MIs) are encouraged to apply; however, no portion of this announcement is set aside for HBCU and MI participation. In case of difficulties in determining the appropriate AFOSR addressee, proposals may be submitted to:

AFOSR/PKC
110 Duncan Avenue, Suite B115
Bolling AFB, DC 20332-0001

This announcement is AFOSR BAA 94-1 and supersedes the AFOSR Air Force Defense Research Sciences Program announcement of October 8, 1992. This announcement is open-ended until revised and should be referenced on all responses.



Directory

Organizational Directory

ORGANIZATION	ADDRESS	NAME AND TELEPHONE NUMBER
Air Force Office of Scientific Research (AFOSR)	AFOSR 110 Duncan Avenue, Suite B115 Bolling AFB, DC 20332-0001	Hellwig, Helmut, Dr. Director (202) 767-5017; DSN: 297-5017; FAX: (202) 767-6213
Contracts Directorate	AFOSR/PK	Hariots, George K., Col. Deputy Director (202) 767-5018; DSN: 297-5018; FAX: (202) 767-6213
Aerospace and Engineering Sciences Directorate	AFOSR/NA	Hawkins, Ed, Mr. Director (202) 767-4945; DSN: 297-4945; FAX: (202) 404-7951
Chemistry and Materials Sciences Directorate	AFOSR/NC	Chang, Jim C. I., Dr. Director (202) 767-4987; DSN: 297-4987; FAX: (202) 767-4988
Physics and Electronics Directorate	AFOSR/NE	Ball, Donald L., Dr. Director (202) 767-4960; DSN: 297-4960; FAX: (202) 767-4961
Life and Environmental Sciences Directorate	AFOSR/NL	Wittmann, Horst R., Dr. Director (202) 767-4984; DSN: 297-4984; FAX: (202) 767-4986
Mathematical and Computer Sciences Directorate	AFOSR/NM	Berry, William O., Dr. Director (202) 767-4278; DSN: 297-4278; FAX: (202) 404-7475
Academic & International Affairs Directorate	AFOSR/NI	Holland, Charles J., Dr. Director (202) 767-5025; DSN: 297-5025; FAX: (202) 404-7496
European Office of Aerospace Research and Development	EOARD/CC 223/231 Old Marylebone Rd. London NW1-5th United Kingdom or EOARD/CC PSC 802, Box 14 FPO AE 09499-0200	Rhoads, Harold S., Col. Director (202) 767-4969; DSN: 297-4969; FAX: (202) 767-5012
Frank J. Seiler Research Laboratory (FJSRL)	FJSRL/CC 2354 Vandenberg Drive, Suite 6F13 USAF Academy, CO 80840-6272	Crimmel, William W., Col. Commander (01) 44-71-409-4376; DSN: 235-4505; FAX: (01) 44-71-402-9618
Asian Office of Aerospace Research and Development (AOARD)	AOARD Unit 45002 APO AP 96337-0007	Fujishiro, Shiro, Dr. Director 81-03-5410-4409; DSN: 785-1301; FAX: 81-03-5410-4407
Armstrong Laboratory	AL/CA 2509 Kennedy Drive Brooks AFB, TX 78235-5118	Mohr, George, Dr. Chief Scientist (210) 536-3656; DSN: 240-3656; FAX: (210) 536-2371
Aerospace Medicine Directorate	AL/AO 2510 Kennedy Drive, Suite 3 Brooks AFB, TX 78235-5119	Herbold, John, Col. Chief Scientist (210) 536-4110; DSN: 241-4110; FAX: (210) 536-2042
Crew Systems Directorate	AL/CF 2610 Seventh Street Wright-Patterson AFB, OH 45433-6573	Burton, Russell, Dr. Chief Scientist (210) 255-2446; DSN: 240-2446; FAX: (210) 255-2781
Operations & Support Directorate	AL/DO 2509 Kennedy Drive Brooks AFB, TX 78235-5118	Benline, Terry A., Col. Director (210) 536-3575; DSN: 240-3575 FAX: (210) 255-2371
Human Resources Directorate	AL/HR 7909 Lindbergh Drive Brooks AFB, TX 78235-5000	Ruck, Henrick W., Dr. Chief Scientist (210) 536-3605; DSN: 240-3605; FAX: (210) 536-2902
Environics Directorate	AL/EQ 139 Barnes Drive, Suite 2 Tyndall AFB, FL 32403-5323	Katona, Michael, Dr. Chief Scientist (904) 283-6272; DSN: 523-6272 FAX: (904) 283-6064

(DSN numbers are available only on Department of Defense telephones.)

Due to the recent restructuring of the Air Force laboratories, this preliminary list is subject to change.

Occupational & Environmental Health Directorate	AL/OE 2402 Edward Drive Brooks AFB, TX 78235-5114	Poitras, Bruce J., Col. Chief Scientist (210) 536-2001; DSN: 240-2001; FAX: (210) 536-2025
Phillips Laboratory	PL/CA 3550 Aberdeen Avenue, SE Kirtland AFB, NM 87117-6008	Janni, Joseph F., Dr. Chief Scientist (505) 846-0861; DSN: 246-0861; FAX: (505) 846-5128
Advanced Weapons Survivability Directorate	PL/WS 3550 Aberdeen Avenue, SE Kirtland AFB, NM 87117-6008	Gaudet, John, Lt. Col. Associate Chief Scientist (505) 846-4040; DSN: 246-4040 FAX: (505) 846-0417
Geophysics Directorate	PL/GP 29 Randolph Road Hanscom AFB, MA 01731-5000	Hendl, Richard G., Dr. Associate Chief Scientist (617) 377-3604; DSN: 478-3604; FAX: (617) 377-5688
Lasers & Imaging Directorate	PL/LI 3550 Aberdeen Avenue, SE Kirtland AFB, NM 87117-6008	Hogge, Barry, Dr. Associate Chief Scientist (505) 846-4735; DSN: 246-4735; FAX: (505) 846-0873
Propulsion Directorate	OL-AC PL/RK 5 Pollux Drive Edwards AFB, CA 93523-7048	Heil, Michael L., Lt. Col. Deputy Director (805) 275-5622; DSN: 525-5622; FAX: (805) 275-5086
Space & Missile Technology Directorate	PL/VT 3550 Aberdeen Avenue, SE Kirtland AFB, NM 87117-6008	Wick, Ray, Dr. Associate Chief Scientist (505) 846-2797; DSN: 246-2797; FAX: (505) 844-5589
Rome Laboratory	RL/CD 26 Electronic Parkway Griffiss AFB, NY 13441-4514	Diamond, Fred I., Dr. Deputy Director (315) 330-4512; DSN: 587-4512; FAX: (315) 330-4037
Command, Control, & Communications Directorate	RL/C3 525 Brooks Road Griffiss AFB, NY 13441-4505	Urtz, Raymond P., Mr. Director (315) 330-2165; DSN: 587-2165; FAX: (315) 330-3807
Electromagnetics & Reliability Directorate	RL/ERG 525 Brooks Road Griffiss AFB, NY 13441-4505	Bart, John J., Mr. Chief Scientist (315) 330-3064; DSN: 587-3064; FAX: (315) 330-7083
Electromagnetics & Reliability Directorate	RL/ERH 31 Grenier Street Hanscom AFB, MA 01731-3010	Roth, Harold, Dr. Chief Scientist (617) 377-3200; DSN: 478-3200; FAX: (617) 377-5040
Intelligence & Reconnaissance Directorate	RL/IR 32 Hangar Road Griffiss AFB, NY 13441-4114	Barringer, Garry W., Mr. Technical Director (315) 330-2976; DSN: 587-2976; FAX: (315) 330-3913
Surveillance & Photonics Directorate	RL/OC 26 Electronic Parkway Griffiss AFB, NY 13441-4514	Youngberg, James W., Lt. Col. Deputy Director (315) 330-7781; DSN: 587-7781; FAX: (315) 330-3703
Wright Laboratory	WL/CA, Bldg. 45 2130 Eighth Street, Suite 11 Wright-Patterson AFB, OH 45433-6523	Richey, G. Keith, Dr. Chief Scientist (513) 255-9400; DSN: 785-9400; FAX: (513) 255-6641
Aeropropulsion & Power Directorate	WL/PO, Bldg. 18 1921 Sixth Street, Suite 5 Wright-Patterson AFB, OH 45433-7650	Garscadden, Alan, Dr. Chief Scientist (513) 255-2246; DSN: 785-2246; FAX: (513) 476-4657
Armament Directorate	WL/MN 101 West Eglin Boulevard, Suite 101 Eglin AFB, FL 32542-6810	Lambert, Samuel C., Dr. Chief Scientist (904) 882-3002; DSN: 872-3002; FAX: (904) 882-8689
Avionics Directorate	WL/AA, Bldg. 22 2690 C Street, Suite 2 Wright-Patterson AFB, OH 45433-6523	Ryles, Jesse C., Dr. Chief Scientist (513) 255-3627; DSN: 785-3627; FAX: (513) 476-4325
Flight Dynamics Directorate	WL/FL, Bldg. 45 2130 Eighth Street, Suite 21 Wright-Patterson AFB, OH 45433-6523	Olsen, James J., Dr. Chief Scientist (513) 255-7329; DSN: 785-7329; FAX: (513) 255-3438
Materials Directorate	WL/ML, Bldg. 653 2977 P Street, Suite 1 Wright-Patterson AFB, OH 45433-6523	Burke, Harris M., Dr. Chief Scientist (513) 255-6825; DSN: 785-6825; FAX: (513) 476-4831
Solid State Electronics Directorate	WL/EL, Bldg. 620 2241 Avionics Circle, Suite 29 Wright-Patterson AFB, OH 45433-6523	Champagne, Edwin B., Dr. Chief Scientist (513) 255-7689; DSN: 785-7689; FAX: (513) 255-6942

Alphabetical Directory

Ball, Donald L., Dr. (202) 767-4960; DSN: 297-4960

Barker, Robert J., Dr. (202) 767-5011; DSN: 297-5011

Berman, Michael R., Dr. (202) 767-4963; DSN: 297-4963

Berry, William O., Dr. (202) 767-4278; DSN: 297-4278

Birkan, Mitat A., Dr. (202) 767-4938; DSN: 297-4938

Chang, Jim C. I., Dr. (202) 767-4987; DSN: 297-4987

Collins, Daniel L., Lt. Col. (202) 767-5021; DSN: 297-5021

Craig, Alan E., Dr. (202) 767-4931; DSN: 297-4931

Dickinson, Stanley, Dr. (202) 767-5021; DSN: 297-5021

Erstfeld, Thomas E., Maj. (202) 767-4960; DSN: 297-4960

Fant, Daniel B., Maj. (202) 767-0471; DSN: 297-0471

Glassman, Neal, Dr. (202) 767-5026; DSN: 297-5026

Haddad, Genevieve M., Dr. (202) 767-5021; DSN: 297-5021

Hawkins, Ed, Mr. (202) 767-4945; DSN: 297-4945

Hedberg, Frederick L., Dr. (202) 767-4963; DSN: 297-4963

Hellwig, Helmut, Dr. (202) 767-5017; DSN: 297-5017

Holland, Charles J., Dr. (202) 767-5025; DSN: 297-5025

Jacobs, Marc, Dr. (202) 767-5027; DSN: 297-5027

Jones, Walter F., Dr. (202) 767-0470; DSN: 297-0470

Kelley, Ralph E., Dr. (202) 767-4908; DSN: 297-4908

Kozumbo, Walter J., Dr. (202) 767-5021; DSN: 297-5021

Kroll, James, Maj. (202) 767-5021; DSN: 297-5021

Lee, Charles Y.-C., Dr. (202) 767-4963; DSN: 297-4963

Lewis, Martin, Maj. (202) 767-6963; DSN: 297-6963

Luhmann, N. C., Jr., Prof. (213) 825-3209

McMichael, James M., Dr. (202) 767-4936; DSN: 297-4936

Nachman, Arje, Dr. (202) 767-4939; DSN: 297-4939

Pavel, Arthur, Col. (202) 767-5018; DSN: 297-5018

Pechenik, Alexander, Dr. (202) 767-4963; DSN: 297-4963

Pomrenke, Gernot S., Lt. Col. (202) 767-4931; DSN: 297-4931

Radoski, Henry R., Dr. (202) 767-5021; DSN: 297-5021

Rhoads, Harold S., Col. (202) 767-4969; DSN: 297-4969

Rosenstein, Alan H., Dr. (202) 767-4960; DSN: 297-4960

Sakell, Len, Dr. (202) 767-4935; DSN: 297-4935

Schlossberg, Howard R., Dr. (202) 767-4906; DSN: 297-4906

Sjogren, Jon, Dr. (202) 767-4940; DSN: 297-4940

Smith, Billy R., Maj. (202) 767-5011; DSN: 297-5011

Suddarth, Steven C., Capt. (202) 767-5028; DSN: 297-5028

Tangney, John F., Dr. (202) 767-5021; DSN: 297-5021

Tishkoff, Julian M., Dr. (202) 767-0465; DSN: 297-0465

Waksman, Abraham, Dr. (202) 767-5028; DSN: 297-5028

Ward, Charles H., Capt. (202) 767-4960; DSN: 297-4960

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